JOURNAL of the SOCIETY of MOTION PICTURE and TELEVISION ENGINEERS

In This Issue

68th Semiannual Convention · Oct. 16–20 · Lake Placid

JULY 1950

High-Speed Photography

This issue of the *Journal* introduces our first High-Speed Photography Question Box, a practical question-and-answer service for research people who employ high-speed or other industrial photographic methods. The prime objective is orientation in the use of these specialized techniques. Questions will state specific problems and, as far as is possible, those asked in one issue will be answered in the next. Look for them on page 122.

68th Convention

Members: Plan now to attend the Fall Convention at the Lake Placid Club. The dates are October 16–20 and Bill Kunzmann, Convention Vice President, promises that all who attend will enjoy the major break with tradition which it will provide. For inside information turn to page 121.

Authors: In case you have neither received nor submitted your authors' forms, get in touch with the Papers Committee Vice Chairman nearest you. You will find his name and address on the inside front cover of the June *Journal*.

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Simplification of Motion Picture Processing Methods

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SUMMARY: The chemical bath formulas and treating methods used in present-day continuous motion picture processing machines were adopted without essential modification from the earlier manually operated rack-and-tank process, to which the long times of treatment were well suited. In continuous processing at high running speed, these long times of treatment require the use of large-size machines of considerable complexity which are costly to build and difficult to operate and maintain. Recent work on rapid processing methods has shown that, with highly active baths and spray application, the times of treatment can be reduced by a factor of 25 to 50, so that equipment can be made smaller and simpler as well as easier to operate and maintain.

With such types of film as can be strongly hardened in manufacture, elevated temperatures are used to accelerate the reactions further and to simplify temperature control without refrigeration. In this case, processing is complete in a minute or less. Even with films which are not hardened to such a degree in manufacture, the total time for processing can usually be reduced to a few minutes by making use of active baths applied by spraying and impingement warm-air drying. The latter films sometimes are hardened in a preliminary bath to gain time by the use of vigorous baths and elevated temperatures if the process comprises a number of successive bathing operations.

The design of equipment to suit the needs of these processing methods is described with reference to the conditions which are met in television work, in the motion picture laboratory and in the field.

Among all the types of photography, motion picture work stands out as that in which the degree of mechanization and the completeness of technical control during the processing operations are greatest. The present high level of quality and uniformity of results bear evidence of the effectiveness of the effort which has been made to improve materials and equipment over the years. While quality has undergone continuous improvement during the last three decades, the running speed of processing machines has increased by a factor of several times, with a corresponding gain in productive capacity.

The chemical processes around which the continuous machine is built, however, have not changed significantly from the day of the hand-manipulated rack-and-tank method for which they were de-

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vised. It is probably fair to say that the chemical process has not been adapted in any way to take advantage of the capabilities of automatic machinery for rapid, precise operation, and that no recognizable trend in machine design has demanded any important modification of the process. Consequently, the present fast-running machine, with its hundreds of transport rollers along a film path thousands of feet in length, is so large and complex that it requires much skill for operation and maintenance and the use of a large amount of associated equipment. Nevertheless, existing equipment of this type is meeting the requirements of the large laboratories, with respect to both the quality and quantity produced, and probably will do so for some time to come. On the other hand, this type of equipment is too bulky and inflexible for use in certain special applications. The present work is concerned primarily with the latter cases in which requirements are unusual, but the results obtained are significant in many respects for general processing practice as well.

Although some simplification in the operation of processing equipment could be achieved by redesigning individual elements and introducing more elaborate control instruments, much more might be accomplished if the time of treatment in the various steps of the process could be shortened by a factor of ten times or more. Even in cases where a reduction of the time of processing is not in itself of paramount importance, shortening of the film path and diminution in the volume of the baths would permit radical changes in design and in methods to provide more automatic operation.

About twenty years ago it appeared that a photographic film intermediate step would be required in television for the sake of the additional sensitivity it offered in the pickup from original subjects and in some cases for light amplification and image storage at the receiving point. In response to these needs, considerable work was done on rapid, highly automatic processing methods,[1–3] some of which have found application in other types of photography[4,5] and appear to offer promise in present-day motion picture work. More recently, the requirements of military use have led to the development of stepwise processing methods[6,7] in which the time of treatment was shortened by a factor of 25 to 50 times, compared to that of ordinary practice, by the use of highly active baths, elevated temperatures, forceful application of the baths and, to a limited extent, special photographic films.

The strenuous treatment employed to obtain the most rapid processing in some of the cases cited would cause serious softening of the emulsion gelatin unless it was hardened either in manufacturing or at

a suitable stage in the processing. At the time when further study of applications of these methods to motion picture work was undertaken, the hardening of some of the lower-speed printing and sound-recording films had been increased sufficiently in manufacture and effective methods were available for hardening other films in processing. Preliminary studies of washing and drying techniques had indicated that great acceleration of the process was possible by adoption of forceful jet impingement methods in place of the low velocities and slow renewal characteristic of current practice.

EXPERIMENTAL EQUIPMENT

Work on rapid processing published up to the present time has revealed little as to the uniformity and image quality attainable for motion picture use. Since temperatures would often be well above ambient and short times of treatment would prevail with the methods considered, automatic equipment with thermostatic control would be needed for the investigation. Also, in due course, practical equipment would be required for studies of the techniques for applying treating baths and drying air.

Two major units of continuous processing equipment were therefore built and used in this work, although supplementary tests were carried out on a variety of other equipment. The first machine was a highly compact, semiportable unit occupying about 2 cu ft of space, and the second was intended for operation at the rate of 90 fpm and was proportionately larger. Based on preliminary tests, the design in both cases provided for the complete processing of the highly hardened Eastman Fine Grain Release Positive Film in a minute or less.

Semiportable 16-Mm Machine

The first continuous machine used in the present work was designed to give about 5-sec immersion treatment in developer, rinse, fixing and washing tanks, respectively, at a running speed of 8 fpm. It was intended to be highly compact, easy to thread, and simple in construction. Figure 1 shows the machine with tanks removed, revealing the film in normal running position. Threading is accomplished by drawing the film from the supply box at the lower left across the upper rollers standing between the several tank compartments into which loops are formed when the rack assembly carrying the lower rollers is slid down into position. Upon leaving the last tank at the right, the film passes through the squeegee rollers and then around the two large heated drive drums on which drying is effected

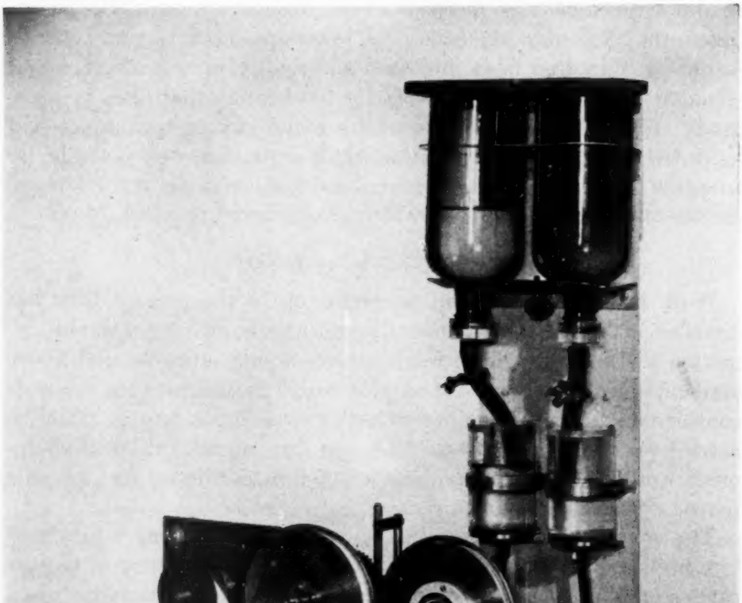

Fig. 1. 16-Mm continuous rapid processing machine, with tank section removed to show film path.

with the help of compressed air discharged against the emulsion surface through orifices in the arcuate distributing pipes. The dried film is wound up on the reel at the top left. When the rack frame is lowered to form the loops, the drive is automatically connected by radial engagement of a spur gear on the shaft of one of the interlinked drums. One ounce of processing bath is then run into each tank and brought to working temperature by a thermostatically controlled heating element immersed in the water jacket, which can be seen with the tank assembly in Fig. 2. When the working temperature is

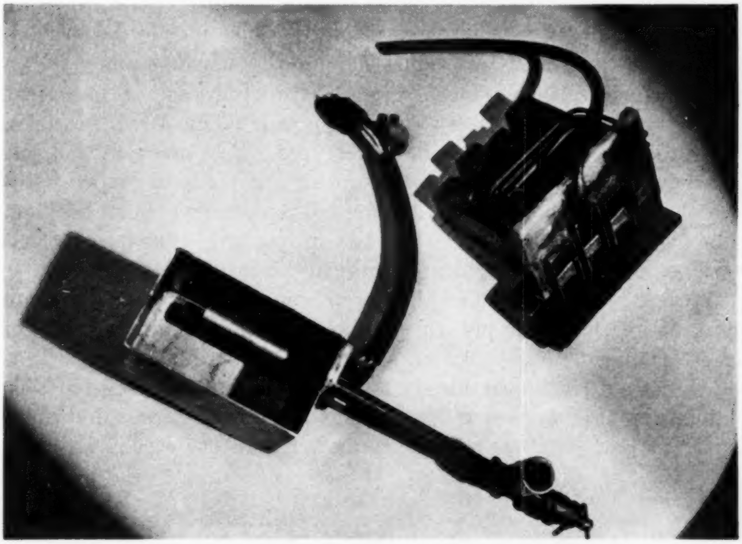

Fig. 2. Tank section for 16-mm rapid processing machine; heat-exchanger jacket at left, and four processing tanks with preheating coils at right.

reached, as evidenced by a heater pilot lamp bull's-eye, wash water and compressed air are turned on and the drive is started. Developer and fixing-bath replenishers flow continuously under control of throttle valves from the constant-level chambers above at the back and reach the work tanks after passing through tempering coils (Fig. 2) in the water jacket. Just below the drying drum at the right (Fig. 1) is a transparent box enclosing an additional film loop and two water spray nozzles which can be used when thorough washing is desired or by-passed if a minimum processing time is required.

At a film speed of 8 fpm, a 4.8-sec time of treatment is provided in each bath, which is sufficient for normal processing at 125 F (degrees Fahrenheit) when Kodak D-8 Developer and the Kodak Rapid Liquid Fixer (with Hardener) are used with Eastman Fine Grain Release Positive Film, Type 7302. Except in the spray wash section, the baths are neither agitated nor circulated except as a result of film motion.

While the rate of reaction in the chemical baths was not affected significantly by the lack of agitation, development uniformity and tone reproduction were not always up to commercial standards for continuous-tone work. Hot-drum drying, while efficient from the viewpoint of heat transfer, was prone to cause mottle pattern because of the practically unavoidable nonuniformity of contact.

Nevertheless, this apparatus has served its purpose well in a great variety of experimental work involving a wide range of temperatures, chemical treating methods, and film types. The machine was sufficiently light-tight for daylight operation and could be loaded without the use of a magazine if the film had removable opaque backing. The high-*p*H developers were effective in removal of the backing material with the aid of a light frictioning in the bath.

With the addition of a small air-compressing pump and a pressure tank for the water supply, this equipment required only a source of electric current for installation almost anywhere. Therefore, it has been sent out frequently for use in tests involving other less portable equipment,[8] for processing in an airplane, and for lecture-hall demonstrations, and has given regular service in laboratory work.

A 90-fpm Machine

In order to evaluate rapid processing for such applications as theater television and motion picture laboratory work where highest standards of quality and uniformity would have to be met, a faster machine with more effective means for bath agitation and for drying was needed. A 90-fpm speed was decided upon with intense spray application of chemical solutions and wash water to secure the rapid and uniform renewal at the film surface which would be requisite with the short times of treatment.

Provision was made for times of treatment as short as 5 sec in each bath, with the possibility of increase to 10 or 15. The film was supported on a cylindrical drum during the 5-sec drying treatment so that forcible air jets could be applied. Longer times would be attainable by reducing the running speed. Unless the film splicing and roll changing could be made fast and entirely automatic, the usual

type of elevator and splicer sections would be disproportionately large in comparison with the rest of the machine. These elements were, therefore, omitted entirely, inasmuch as a machine with such a short processing time and film path could be stopped at the end of each roll, at least in experimental work.

Arrangement of Parts

In the front elevation of the machine in operating condition (Fig. 3) starting from the left are seen the supply roll, the developer cabinet,

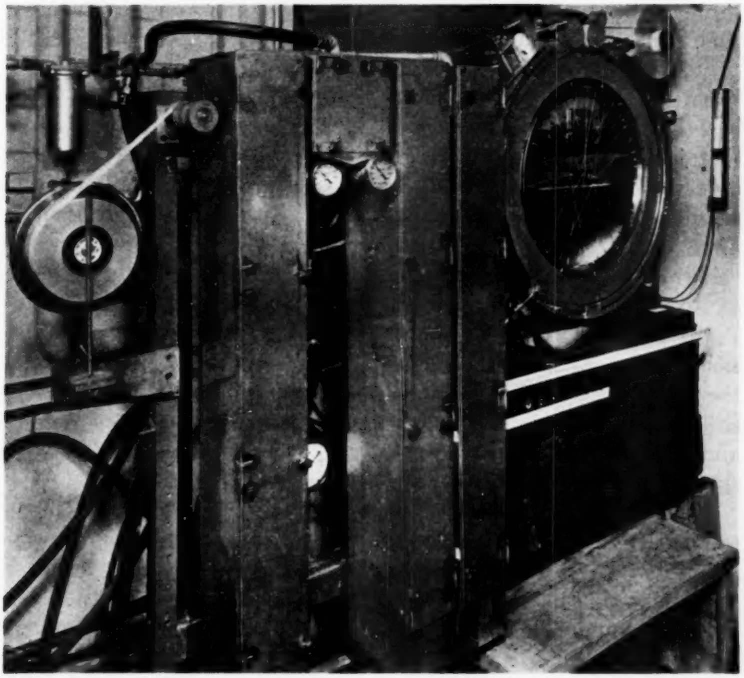

Fig. 3. 90-Fpm 35- and 16-mm rapid processing machine.

a short section for rinsing, the fixing and washing cabinets, the pneumatic squeegee, the drying drum, and at the top right, the film-drive roller and the windup. Figure 4 is a closer view of the bathing section with the doors opened as for threading to show the arrangement of the film loops and spray nozzles. These figures are essentially the same as those shown at the SMPE Chicago Convention in the spring

of 1947, when the method was discussed in a preliminary way. This machine is about 6 ft long, 7 ft high, and 2 ft deep.

In the three larger cabinets, the film traverses the familiar flattened helical path over free-running rollers supported by the parallel upper and lower shafts on 42-in. vertical centers. The lower shaft is fixed in position and does not rotate, while the upper shaft is mechanically driven at a speed somewhat greater than that at which the rollers are turning with the moving film. With the upper shaft somewhat larger than the lower, this overdrive of a few percent largely neutralizes the frictional drag and relieves film tension. The film moves through the small rinse cabinet in a straight line so as to provide a time of about one-half second.

Figure 5 shows the circulatory path of the developer and fixer. From the sump at the bottom of the rectangular tank at the upper left, the developer goes through the pump, a heater and a filter, past the thermostatic switch and thermometer to the spray nozzle system. In order to simplify piping while obtaining complete spray coverage of the film, the nozzles were located inside the film loops and directed upward and transversely to the film at an angle of about 30° to the vertical. It had been determined in advance that films which are as strongly hardened in manufacture as Eastman Fine Grain Release Positive Film, Type 5302 (or 7302), could safely be run with the emulsion in contact with a reasonable number of smooth rollers, as long as the film surface was kept completely wet and proper principles were adhered to in design and maintenance. Stainless-steel construction and piping were used, where necessary, with commercially available spray nozzles of the same material.

The pneumatic squeegee used was of a type employed on many conventional processing machines and consisted of a hollow box with roller-guarded slotted openings at opposite ends.[9]

While a considerable variety of drying schemes were of interest, the basic equipment on this machine consisted of distribution piping for the drying-air jets and a radiant-heating ribbon of Nichrome surrounding the drum and concentric with it and at a distance of about one-half inch from the film. In some of the work, a cabinet dryer located above the drum was used instead.

Applications of Spray-Type Machine

Although the ability of this type of equipment to do good work had been demonstrated prior to the preliminary report presented in the spring of 1947, much remained to be learned both as regards features of the equipment design and as to the application of a rapid

processing technique to films of widely varying properties. Because of the lack of automatic equipment for preliminary study on a test-tube scale and the need for information on processing-machine design, the experimental work was carried out mainly with the continuous machines under conditions of practical use and will, therefore, be discussed on the same basis.

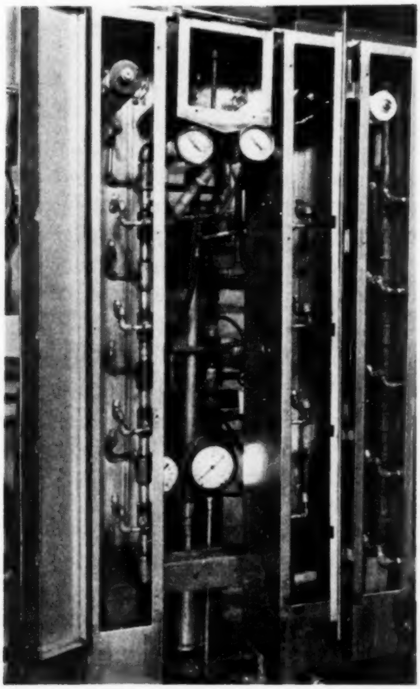

Fig. 4. Spray processing chambers of 90-fpm machine, with doors opened to show position of nozzles.

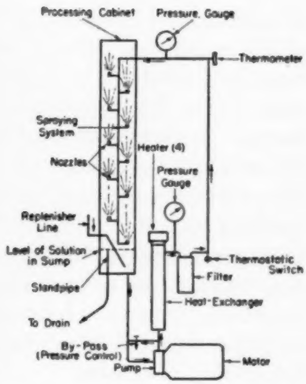

Fig. 5. Circulation system in 90-fpm rapid processing machine.

THEATER TELEVISION; FINE GRAIN RELEASE POSITIVE FILM

In the processing of Eastman Fine Grain Release Positive Film in theater television use, both compactness of equipment and extreme curtailment of the processing time were required. A study was made, therefore, of processing methods for use in the 90-fpm spray-type machine, with the object of arriving at a ½-min total time for processing, including drying.

The 40-fold reduction in developing time from 3½ min to 5 sec was achieved by the combined effect of a very active developer, such as Kodak SD-27 (formula below), and an elevation of temperature from 70 to 120 F.

Kodak Rapid Developer SD-27

Water, about 90 F (32 C)	750.0 ml
Kodak Elon Developing Agent	5.0 g
Kodak Hydroquinone	45.0 g
Kodak Sodium Sulfite, desiccated	90.0 g
Kodak Sodium Hydroxide (Caustic Soda)	40.0 g
Kodak Potassium Bromide	10.0 g
Kodak Anti-Fog No. 1 (Benzotriazole)	1.0 g
Water to make	1.0 l

Some difficulty was experienced with nonuniformity of density until it was realized that complete wetting of the film must be attained in the first one-half second which, of course, constituted 10% of the total developing time. The use of a wetting agent, such as "Tergitol" Penetrant 08 (Manufactured by Carbide & Carbon Chemicals Div., Union Carbide & Carbon Corp., New York, N.Y.) at a concentration of 0.1% in the developer was helpful but insufficient except in combination with proper application of the bath at the start. The practice finally adopted consisted in momentary immersion in developer contained in a small vestibular trough at the cabinet entrance followed immediately by a strong spray blast. The wetting agent was retained for its effect in preventing a type of marking caused by small scattered airbells. Developer from the first nozzle maintained sufficient depth in the trough to insure wetting of the entering film and sealing of the opening against the entry of air. Additional pressure of developer at the nozzles above the minimum of 30 psi required to produce the full spray pattern had no effect on the quality of results.

Rinsing

Adequate rinsing was obtained in the 9-in.-long straight pass through the next small cabinet, which was equipped with two spray nozzles directed upward toward the emulsion surface and one downward toward the film support. All three were supplied with tempered water. Any deficiency in rinsing tended to cause the typical yellowish fog which is formed when residues of a vigorous developer are present in film as it enters a fixing bath. Soft-rubber wringer rollers located at the entrance and exit openings of each cabinet are helpful in minimizing carry-over and leakage.

Fixing

Complete fixation of the Eastman Fine Grain Release Positive Film in 10 sec at 120 F, was attained by the use of an ammonium thiosulfate bath, such as Kodak Rapid Liquid Fixer (with Hardener), at a dilution of one part of the commercially supplied concentrate to three parts of water. While there is no need to harden the film in question for the sake of toughening it, inclusion of the hardening constituent in the bath has been found desirable to make drying easier.

Washing

The spray system for applying wash water was essentially similar to that used in the developing and fixing tanks and used water at a rate of about 1.5 gpm. At a wash-water temperature of 120 F with the film in question, hypo and silver residues reached the level sometimes referred to as "commercial" in 5 sec and as "archival" in 10 sec or less.

Squeegeeing

When rapid drying is to follow, loose water must be removed more uniformly and completely than in normal processing. Spots and streaks produced in drying when squeegeeing is inadequate cannot be prevented by the liberal use of an efficient wetting agent in the wash water, presumably because the rate of redistribution is too slow to keep up with the needs in the two or three critical seconds of the drying process. Of necessity, reliance was placed, therefore, on the liberal use of compressed air. About 30 cfm (atmospheric) were used at 15 psi.

Drying

Measurements of the water content of Eastman Fine Grain Release Positive Film processed in the manner described here have shown that the water absorption is ordinarily less than in conventional processing and that almost all of it is by the emulsion layer.

The drying equipment used in this work is designed to hasten the evaporation of water mainly from the emulsion surface while the film support lies in contact with the smooth chromium-plated drum shielded from air circulation. No provision is made for application of heat except from the emulsion side. In the first experimental work, drying air at room temperature was supplied in forceful cross streams from orifices of 0.040 in. in diameter near the edge of the film

at intervals of one-half inch on either side. Considerable dependence was placed upon the supplementary effect of radiant heat provided by the near-by fluted Nichrome ribbon which was operated near the glow point, i.e., about 1000 F. With this open radiator, the machine was suited only for use with safety film.

Previous studies had shown that for proper use of radiant heat the flow of air over the film surface should be sufficient to prevent any large elevation of the temperature of the film if severe physical effects were to be avoided. In the present work, therefore, an ample air stream was used to hasten the drying so that the condition of the film was good except for a small and unimportant increase in brittleness. Nevertheless, the proximity to the threshold of physical change was indicated by a tendency to increased glossiness of the emulsion surface. Any substantial increase in air flow was impractical because of the loss in total efficiency of the system caused by the cooling of the bare radiant ribbon by the air deflected back against it from the film and the air distribution piping.

More intensive air impingement with a new distributor was then tried with success. In place of the original cross-flow system, a ladderlike structure of tubing was installed at a distance of about one-half inch from the film. The four 0.040-in. orifices in each rung were staggered relative to the width of the film. With 40 rungs along the 7.5-ft film length, for example, 40 cu ft of air at about 160 to 170 F and at 10 lb manifold pressure were required for the Fine Grain Release Positive Film. In general, lower temperatures are preferred, with a greater number of rungs delivering a proportionately increased volume of air. An improved design is now being built for the systematic study of temperature, pressure, orifice diameter and spacing. Preliminary data indicate that groups of orifices of the type mentioned here, located at intervals of 1 in. or less and delivering a total of 100 cu ft of air at 90 F, will be sufficient.

Cabinet Dryer

When, for any reason, the drying path is increased beyond 10 ft, the drum-type dryer is too cumbersome and will be replaced by a cabinet dryer in which less forcible air streams will be applied over a proportionately greater length of less firmly supported film. A cabinet dryer of this type is illustrated in Fig. 6.

In the dryer, the film travels, emulsion side outward, in the usual helical path around upper and lower rollers of the rack. Drying air is delivered perpendicularly to the emulsion surface from the supply plenum through a very large number of staggered small orifices or

through numerous narrow slits, each covering the width of the film strand. Pressure is maintained in the plenum by a blower which takes air from the vicinity of the film strands and fresh air from a dampered intake pipe. Air leaving the blower flows through the thermostatically controlled heater and then enters the several sections of the plenum.

The slits or groups of orifices should be spaced in such a way that the film in each strand passes them at a rate of 15 or more a second. Air velocities should be upward of 100 fps. The dimensions of the openings will depend upon the supply pressure. The total volume of air necessary for drying Eastman Fine Grain Positive Film at 120 F will be of the order of 75 to 100 cfm, measured at atmospheric pressure.

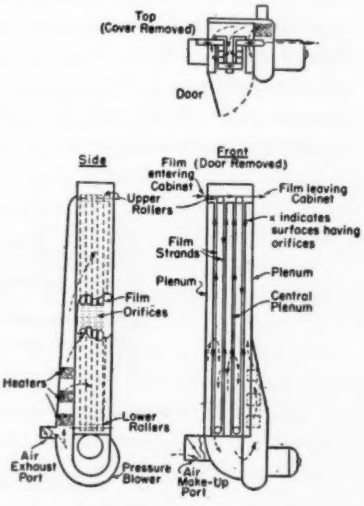

Fig. 6. Cabinet-type rapid film-dryer employing numerous jets of high-velocity, heated air.

The essential feature of the cabinet as well as of the drum design is the frequent sweeping of the emulsion surface by forcible streams of unsaturated warm air. During the 5 sec the film is in the drum dryer, the force of the air blast is so great that the film must be supported rigidly at all times. When 10 to 20 sec of time are available, sufficient support may be provided by a few backing rollers or by balancing air jets applied to the film support.

By the use of the methods and equipment discussed here, the requirements of theater television and the like for simplified, automatic processing of Fine Grain Release Positive Film in a restricted space can be met. Depending upon the requirements for quality and permanence in a given case, the time of processing, including drying, may be reduced below the 25 to 40 sec employed in the practice described here.

USE IN MOTION PICTURE LABORATORY

At present, rapid processing equipment might be adopted in commercial laboratory work because it requires less space and entails smaller capital outlay than conventional equipment. Justification

might be on this basis where additional equipment is needed for a specific task during a limited period of time. In special situations the simplified temperature control requiring no refrigeration, which is enjoyed when the processing temperature is well above ambient, will be of importance. Occasionally, equipment and a method of this type will be valuable because the delay in processing before a short length of film is available for subsequent use is reduced.

In many of these cases, reduction of the processing time below 2 or 3 min would not be necessary and greater running speed even with proportionately larger size might be desirable. A longer film path could be adopted for a motion picture laboratory machine in which highest quality of results is of prime importance and to permit the use of more dilute baths, possibly in a cascade flow through two tanks for economy. With more time for washing, savings could be effected by heating water only to 70 F.

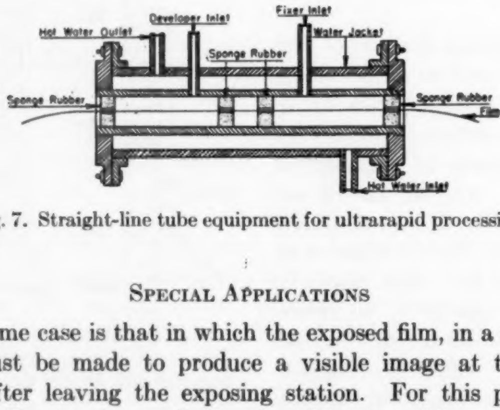

Fig. 7. Straight-line tube equipment for ultrarapid processing.

Special Applications

An extreme case is that in which the exposed film, in a continuous length, must be made to produce a visible image at the earliest moment after leaving the exposing station. For this purpose, in which the film can be used directly without washing or drying, a straight-line machine of the type illustrated in Fig. 7 was devised by one of the authors about 1937. It consisted of a jacketed tube 2 ft long separated into three compartments by means of sponge-rubber plugs held in place by friction with the tube wall. The device was assembled with the leader film passing in a straight line from one compartment to the next through knife cuts in the sponge-rubber plugs. The end compartments about 8 to 9 in. long were filled with developer and fixing bath, respectively, while the smaller space in the middle was empty. The exposed film was attached to the leader and drawn through the baths at the rate of about 100 fpm so as to provide about one-half second in each bath. The highly hardened, low-speed

Kodalith Type film was used with the strongly alkaline Kodak Developer D-9 and an ammonium thiocyanate fixing bath at about 150 F. The latter was made up in the proportion of 15 g of the salt to 5 ml of water and solidified at room temperature. Equipment of this type is, of course, very limited in application but it gives some indication of the possibilities when the rapid processing methods and equipment are properly chosen for a special purpose.

ADAPTATION TO PROPERTIES OF FILM

Up to this point the practice of rapid processing has been treated mainly for the case in which the film to be used is so highly hardened in manufacture that it can be subjected to severe chemical treatment at high temperature without causing much swelling or softening of the gelatin emulsion layer. Among the motion picture films regularly supplied only certain of the lower-speed types are hardened to this degree during manufacture. In addition, a few special photographic films have been made for applications where certain limitations in properties and restrictions in handling can be accepted. At the present time it is not possible to make commercially satisfactory high-speed negative emulsions hardened to this degree, although progress is being made.

In order to extend the benefits of the rapid processing procedure to the emulsion types which are not available fully hardened, modified techniques have been studied in which supplementary hardening is given at the start of processing or in which the severity of the treatment is moderated with some concession in length of treating time.

Method with Prehardener

The use of a prehardening bath, such as Kodak Prehardener SH-5, is satisfactory with most types of high-speed negative films and permits subsequent development at temperatures up to 125 F, but consumes from 1 to 4 min in various cases. However, this treatment[10] removes all obstacles to the use of the strenuous rapid processing treatment without causing any significant loss of emulsion speed or image quality.

From the prehardener the film can go directly to a vigorous developer, such as Kodak Rapid Developer SD-26. This is followed by rapid fixing, washing and drying procedures of the type discussed in the preceding sections. Times of treatment for the higher-speed negative materials must be appropriate for the combination of film type and processing baths chosen but will usually be several times as long as for Fine Grain Release Positive Film.

When it is imperative that the time of prehardening be reduced, the temperature in this prebathing can be elevated to 125 F if the SH-5 is modified by the addition of 100 g of anhydrous sodium sulfate, and 45 ml of formalin per liter. High-speed negative films can be fully hardened in this bath in 30 sec to 1 min, but when so treated will yield only about one half the normal emulsion speed. The anti-foggant concentration may require adjustment for optimum emulsion speed with a given combination of film type and developer.

Intermediate Method

A preferable scheme of handling the less hardened films including the high-speed negatives is to employ all the features of the rapid processing technique such as the use of rapidly acting baths, the spray bathing and washing, and impingement warm-air drying, avoiding only the use of high temperatures. In this way, the high-speed negative films can be processed completely at 70 F to give good-quality images in 4 min, that is, in one tenth the usual time, by the use of Kodak Rapid Developer SD-26 (formula below), Kodak Rapid Liquid Fixer (with Hardener), spray washing, and impingement warm-air drying, each for 1 min. A 2-sec spray rinse with water is sufficient between developing and fixing.

Kodak Rapid Developer SD-26

Water, about 90 F (32 C)	750.0 ml
Kodak Elon Developing Agent	20.0 g
Kodak Sodium Sulfite, desiccated	60.0 g
Kodak Hydroquinone	20.0 g
Kodak Sodium Hydroxide (Caustic Soda)	20.0 g
Kodak Potassium Bromide	10.0 g
Cold water to make	1.0 l

With the drying air moving at high velocity over all parts of the film, the temperature of the wet emulsion approaches the wet-bulb temperature which is below 80 F for a dry bulb of 120 F, even when the air is taken into the system at 70 F and 70% relative humidity. A further margin of safety against softening of the emulsion can be obtained where required by an increase of 1 min in the time of treatment in the hardening fixing bath, which should be obtained preferably by the addition of a second fixing-bath cabinet, into which the replenisher bath is fed in a two-stage counterflow system.

Composition of Processing Baths

The formulas given here have been found useful in practical applications but will require modification to suit the needs of individual

film types, the limitations and peculiarities of equipment, and to meet the chemical and economic requirements of replenishment and silver recovery. Additional information on the chemistry of rapidly acting baths will be found in a series of papers by J. I. Crabtree and his associates[11–14] on rapid processing and on low- and high-temperature processing.

Because of the short times and intense agitation used in practice, preliminary tests with hand manipulation are of limited assistance in selection of chemical bath formulas, and should be followed by tests on a typical element of the machine design under consideration before final decisions are made. For example: the characteristic curve may show a drooping shoulder with quiet immersion development; high fog may be caused by excessively slow transfer from developer to rinse, insufficiently rapid renewal of rinse water, or lack of agitation in rinsing; yellow stain which may be difficult to eliminate in hand tests without use of an acid stop bath is easily overcome in the machine by forceful spray rinsing with water.

An unusual characteristic of the current variable-density sound-recording film was observed when high-activity hydroquinone or Elon-hydroquinone developers were adopted for rapid processing. When development in these baths was carried to the point where the normal low-contrast curve was obtained with low-intensity exposures, a contrasty continuously upcurving characteristic was found with high-intensity short time exposures such as are used in sound-recording or in kinescope photography. The effect was observed at 70 F as well as at higher temperature. Normal curve shape was obtained by the addition of 10 g of sodium thiosulfate per liter to the rapid developer. The effect of exposure intensity level on curve shape with normal developers is very small.

It has been supposed that excessive consumption of developer might occur with spray application of warm developer. In practice, this is not a serious problem since the air in a small developer cabinet is insufficient to oxidize any large amount of sulfite, and renewal of air can be kept small by the use of the tight seals which are required for other reasons. Nevertheless, troublesome aerial fog was encountered in one case, even when extra precautions were taken to reduce the amount of air leakage. This difficulty was eliminated when the developer alkalinity was lowered a few tenths of a pH unit below the critical point for aerial fog propensity—near 12.0—found by H. D. Russell and M. D. Little, of these Laboratories (private communication).

In connection with the increasing use of spray application of de-

velopers, the relation between features of design of a chemical recirculation system affecting aeration, and the economics of the developing agent and sulfite consumption have been studied by G. I. P. Levenson.[15] He concludes that serious losses can occur when air is introduced into a developer by spraying or other means, especially if the volume of developer in a recirculation system is large. His findings indicate the desirability of extremely small circulatory systems relative to the rate of film handling, as exemplified by the spray developing unit described in the present paper.

Effect of Temperature Elevation

As stated by Crabtree,[13] the rate of development generally increases by a factor of about 2 for each 15 F rise in temperature. The acceleration of fixing by elevation of temperature is much less. Washing of film can be speeded up greatly by rapid renewal of water at the film surface but the influence of temperature elevation, while favorable, requires further study. Unnecessarily high temperature of the wash water should be avoided, both to prevent swelling and softening of the gelatin emulsion and to economize power in water heating. The effect of temperature variation in rapid processing has proved to be about the same per degree as in conventional 70 F processing.

Quality of Rapidly Developed Images

Up to the present time, no systematic study has been made of the effect of rapid processing on the structure of the developed silver image to discover the effect on resolution, graininess, etc. However, observation on images developed, fixed, washed and dried in times of 5 to 10 sec, respectively, by projection and in photomicrographs has shown little that is unusual. In certain cases, evidence has been obtained of incompleteness of treatment near the bottom of the emulsion layer with a development time of 5 sec even though the emulsion speed and quality were about normal. This deficiency has been found to increase when the treating time was reduced to 1 second, for example, especially if the compensatory adjustments in developer activity and temperature were not sufficient to assure normal completeness of development. The use of elevated temperatures appears to offer no promise of a significant increase in emulsion speed nor of improvement in graininess. Anyone contemplating the use of high-temperature processing with the softer types of emulsion should make sure that the supplementary hardening in processing is always ample so that graininess will not be produced as a result of incipient reticulation.

Mechanical Condition of Processed Film

A marked embrittlement of a type which is not removed by equilibration with an atmosphere of 70% relative humidity is observed occasionally when radiant heat is used improperly in drying. The condition appears to be caused when the film reaches an excessively high temperature in the course of drying and can be largely corrected by rewetting the film and drying it under more favorable conditions. It is not a direct consequence of rapid drying but rather of overheating during drying.

Almost all of the heat which goes into the drying process is accounted for as the latent heat of evaporation of the water so that, unless evaporation is retarded by the accumulation of moisture vapor above the film surface as a result of insufficiently high velocity of the drying air, a high rate of heat input produces only a moderate rise in temperature of the film. Therefore, a first concern in designing a drying system is to have proper velocity and distribution of the air. Only when this is assured is it safe to introduce the large amount of heat which will be required for rapid evaporation of water.

Effect of Rapid Processing on the Film Support

Up to the present time, no detrimental effects of rapid processing on the film support have been observed when temperatures and physical handling were reasonable. As the temperature actually attained by the film is raised above 125 F, additional care is required to limit the tension applied because the film becomes more susceptible to plastic deformation.

ADVANTAGES IN USE OF RAPID PROCESSING

Some of the advantages obtained by the use of the rapid processing technique are as follows:

1. Elimination of delay in obtaining completed film.
2. Simplification of equipment design, which affects construction, maintenance and use.
3. Reduction of volume of baths, especially if spray application is used, thereby reducing the amount of space required and simplifying chemical control.

Some of the disadvantages of the methods considered are:

1. Increased chemical consumption in certain cases where concentrated baths are replenished rapidly.
2. Increased power consumption when certain extreme requirements as to operating characteristics or size are imposed.

Choice of Type of Equipment

It is apparent that when the operations in processing are shortened by a factor of 10 to 50 times or more, attractive possibilities are offered. However, there is no universally best design for equipment to be used with rapid processing methods. Instead, the design must be chosen in any particular case according to whether the emphasis is to be on compactness, curtailment of the time of processing, simplification of operation, etc. General comments on design of equipment are given in Appendix I and details in regard to components in Appendix II.

Acknowledgments

The authors are glad to acknowledge the valuable contributions made to this work by Norman A. Exley, of these Laboratories, particularly in the work on the "intermediate method" by which the softer high-speed negative films can be processed rapidly without the use of a prehardening bath. They also desire to express their thanks for the generous assistance in problems of equipment design given them by the engineering personnel of the Eastman Kodak Co.

Rochester 4, N.Y.
September 28, 1949.

Appendix I. Comments on Design of Equipment

1. Film Path. In applications where unskilled operators will use the equipment, threading should be extremely simple, or else fully automatic. However, unless an ultrarapid process is employed, the longer film-path length of fast-running machines must be sinusoidal or helical for the sake of compactness. In order to cut down the horizontal length of the machine and the number of film-transport rollers, the film loops could be lengthened, but when the span between supporting rollers exceeds about 5 ft it becomes increasingly difficult to keep the film in position under the action of forceful jets. The use of drums is limited practically by their bulk, even if the film makes more than one turn around them.

2. General Arrangement. With equipment such as the 90-fpm unit, a turn-around path could be used to place the start and finish, side by side. The machine could then be located in an alcove on a roll-away truck.

3. Number of Stages. As stated previously, the provision of more than a single stage in the bathing treatments where space restrictions are not extreme gives desirable latitude in formulating baths and makes possible more economical operation.

4. By the use of stepped-roller shoulders and the interposition at suitable points of fully supporting soft-rubber rollers, 16- and 35-mm film can be run alternately without pause.

5. To avoid excessive carry-over or dilution of the concentrated solutions which would otherwise occur in the necessarily very short cross-over paths, soft-rubber wringer rollers or other squeegee devices must be used.

6. Film Drive. In the equipment described, the film receives positive drive at a single roller near the wind-up. This is made possible by the shortness of the film paths and by the reduction in film-dimensional change in the shortened processing times. As the length of the film path and the number of rollers is increased to provide for additional stages of treatment, it is to be expected that provision for relief of accumulated film tension will be required.

7. Spray Application. Forceful application of an over-all fine spray appears most practical for vertical film strands. A flooding-type low-pressure nozzle has the advantage of operating at low pressures and does not clog easily. However, it is usually applicable only to horizontal film paths. Widely spaced solid stream jets are usually not suitable.

8. Splicing and Roll Handling. Suitable rapid automatic splicing is needed with fast machines to eliminate the need for bulky film-reservoir elevators. Developments in heat splicers show promise. In low-speed machines, threading can be made so simple that leaders can be dispensed with. The machine can be stopped momentarily for rethreading after the tail end of the preceding roll has been allowed to run through.

9. Power Consumption. It should be possible to increase the efficiency of squeegeeing immensely by improvement of the pneumatic method or by introduction of another. Likewise, with the use of air recirculation and with low-pressure fans in place of compressors, power consumption during drying can be minimized. Machines designed for greater economy of power and water consumption with provision for removal of hypo from water[16] and for daylight operation should prove useful for military and other uses in which portability is required.

APPENDIX II. SELECTION OF COMPONENTS

1. Thermometers. When the solutions are rapidly circulated, the temperature can be measured accurately by means of an industrial-type thermometer properly located in the spray-nozzle feed lines. Examples are the Weston Dial Thermometer Model 221-D, Range

0–200 F, and the Rochester Manufacturing Co. Model No. 1758, Range 0–200 F.

2. Thermostats for Liquid Solutions. In the circulatory systems described, the simplest types of on–off thermostats have been used successfully when located immediately downstream of low-lag type heaters. Industrial-type thermostats with thin stainless-steel protective wells, such as the Fenwal Thermoswitch A-7100 (well extra), can be used. In differently arranged systems or in case equipment is to be operated with both refrigeration and heating elements or for long periods without checking, it is likely that more elaborate controls will be required. Tempered water can be obtained most conveniently by the use of thermostatic mixers, such as the "HE" series furnished by Powers Regulator Co.

3. Solution Heater. Highly responsive electric resistance heaters sheathed in stainless steel and fitted for insertion in threaded pipe are well suited to use in the small recirculating systems. For example, in the 90-fpm machine, a 4,000-w multiple-connection Screw-In Immersion Heater, Model No. 3-887, supplied by the American Instrument Co. with U-shaped heating coils, provides for rapid heating in the warm-up period and then operation with lower wattage when the 120 F level has been reached. At an ambient temperature of 70 F and with 70 F replenisher flowing in at the rate of 300 ml a minute, a 1000-w heater must operate almost continuously to maintain temperature at 120 F in the 90-fpm machine described. The switching relay can be made to rearrange the load connections automatically in proper sequence.

4. Solution Heat Exchanger. The heat exchanger can be assembled from standard stainless-steel pipe and fittings chosen to suit the length of the heating coils and to assure full velocity of the circulated liquid.

5. Solution Filters. All spray systems should be equipped with strainers of 50- to 100-mesh wire screen just upstream of the distributing manifold to prevent clogging of nozzles. Stainless-steel cloth is available for this use in any degree of fineness needed. A coarser screen should be installed in the outlet from the sump to protect the pump. A filter, such as the Fulflo (Commercial Filters Corp.) Model ABR-8, but specified in stainless steel instead of the usual brass, can be used with the disposable 8-in. filter cell, 1541 KCOSS-1, which consists of cotton fiber wound on a stainless-steel wire-mesh core. However, the need for a filter should be established relative to the type of use because the rapid purging in these small systems minimizes sludge accumulation.

6. Spray Nozzles. The forceful solid-cone spray required for washing and usually for solution application can be obtained by the use of commercially available nozzles, such as the stainless-steel ⅛ GGSS-1 supplied by Spraying Systems Co. At 30 psi, this nozzle is rated to deliver 0.17 gpm. A diversity of nozzle types are available from several manufacturers and can be obtained in various other materials, such as Monel metal, and hard rubber. In the 90-fpm machine, nine nozzles were sufficient to cover the film in two loops totaling 15 ft in length, while five additional nozzles were needed for an additional loop.

7. Pumps. Several types of pump suitable for supplying the 2 gpm at 30 psi required in the case of the 90-fpm machine are available. Corrosion resistance equivalent to that of "18-8 molybdenum" (American Iron and Steel Institute), Type 316 or 317, is desirable, especially with fixing baths, while Type 304 is suitable for developer. Other highly resistant metal, glass, or plastic materials may be required for use with more corrosive baths, such as bleaches, toning baths, etc.

8. Drying Air Temperature Control. Drying systems in which the air is recirculated present the usual problems of regulation and may require hygrostats as well as thermostats. In contrast, once-through systems which take low-temperature room air and raise its dry-bulb temperature 30 F require only a thermometer and means for manually setting the power input to the heaters if the quality of the supply air is constant. Problems of regulation as well as operation are entailed if the air distribution system has a large thermal capacity or sluggish heaters. Rapidly responding electrical heaters are generally most suitable and should be placed close to the discharge orifices.

9. Air Heaters. A wide variety of electrical heaters are available in forms suitable for the space in which they must be installed.

10. Rollers. Because they were readily available, molded rollers of "non-fogging" Bakelite were used in the 90-fpm machine, even though they were eroded rather rapidly by the hot high-*p*H developer. Rollers were turned from other more resistant plastics or even from stainless steel for some of the other machines.

11. Corrosion-Resistant Construction. In some cases, it will be impractical to solve the problem of corrosion resistance by specifying construction with certain materials. It may then be necessary to plan to renew certain parts from time to time. Considerable assistance can be obtained from the recently published *Corrosion Handbook*[17] and from the booklet, "Materials for the Construction of Photographic Processing Apparatus."[18]

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A 16-Mm Rapid Film Processor

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SUMMARY: The proven practicability of spray processing, coupled with the availability of acetate film bases which will withstand fairly high processing temperatures, enables construction of compact continuous processing equipment for operation at synchronous speed of cameras and projectors. The theory and construction of an experimental equipment are described. Significant performance features are studio print quality, continuous automatic operation and convenient control of process variables. Auxiliary equipment permits reel-to-reel, camera-to-projector or camera-to-reel processing. Possible applications are television network service in connection with video recording, motion picture theaters, laboratory processing of small film batches, and motion picture studio monitoring of critical takes.

Although production of release prints in 16-mm size has increased considerably in the past few years, very few users of 16-mm film have been able to maintain complete processing facilities for preparing their own prints immediately after photography. Recent developments in film bases and emulsions now enable construction of compact high-temperature, continuous processing equipment for this purpose.

Continuous film processors operate on fundamentally the same principle, regardless of their size or their speed of operation. The film travels at a steady rate through a series of processing chambers, where it is developed, rinsed, fixed, washed and dried in accordance with a definite time cycle. Time allotments in the wet stages of the cycle are determined largely by solution strengths and temperatures. In the drying stage, the time allotment is determined by the film water content and by the effectiveness of the drying method. The sum of the separate time allotments is the total processing time. The internal film path is sufficiently long to allow completion of the processing cycle while the film travels through the machine at a predetermined rate.

The physical form of a processor is, however, subject to wide variations, depending on the operating condition for which the particular processor is designed. Commercial bulk film processors are designed for high production quotas, involving film travel rates of at least

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150 fpm. These machines have long internal film paths and use large quantities of developer and fix solutions. They are therefore quite large, requiring one or more rooms for complete installation. Threading is a lengthy operation. The travel time from one end of the machine to the other may be as long as 30 min.

Television film processing introduces a new operating condition, calling for a different type of processor. In this case, the processor

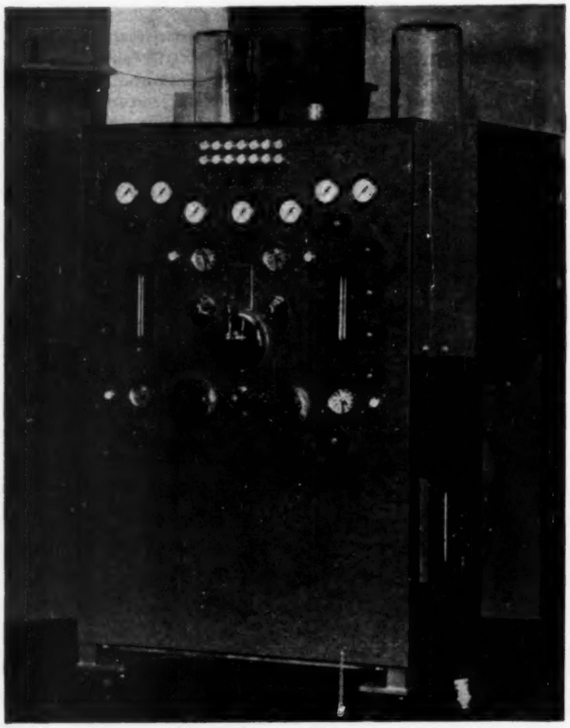

Fig. 1. Rapid film processor, front view.

receives film directly from the camera, and the prime requirement is that the film should be ready for projection in as short a time as possible. The machine developed for this purpose is called a Rapid Film Processor. It differs from a bulk film processor in several respects. The film travel rate is only 36 fpm, which corresponds to the average rate of 16-mm film, exposed at 24 frames/sec. Since the rate is much lower than that required in a bulk film processor, the

internal film path can be much shorter, threading can be simpler, and construction can be much more compact. Solution quantities are correspondingly smaller, and hence there need be no major loss of time and chemicals when starting and stopping the processor. Special measures are, however, required to shorten the processing time in both the wet and dry stages.

The introduction of hardened emulsion type film (Eastman Fine

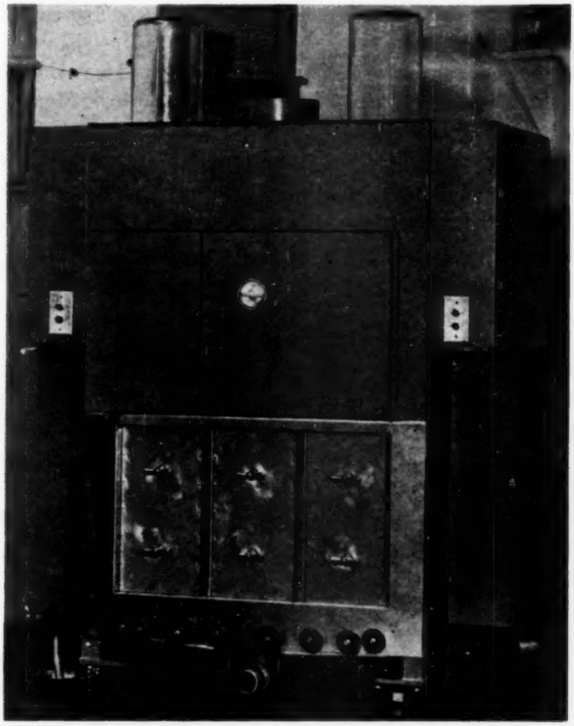

Fig. 2. Rapid film processor, rear view with covers closed.

Grain Release Positive, Type 7302) permits rapid processing at elevated temperatures. A rule-of-thumb formula indicates that processing time is cut in half for each 15 F (degrees Fahrenheit) temperature increase.

The film stock is intended for positive prints, but can be used as a negative material in noncritical applications. It is low in cost and has the added advantage of a fine grain emulsion.

The rapid film processor which will be described is an experimental model. It was constructed primarily for evaluation of space requirements, control features, and film receiving and discharge methods. The flow rates, pressures and temperatures employed in this unit are based on those used in a 35-mm pilot unit which was built by Eastman Kodak Co., under the direction of C. E. Ives and C. J. Kunz (see pp. 3–26 of this issue of the JOURNAL). Controls, indicators and measuring devices have been planned to permit further experimental studies. Simplification of controls will be necessary and desirable for commercial production.

The experimental processor stands 5 ft high, $2^1/_2$ ft deep, and 3 ft wide, exclusive of side film storage compartments. It produces finished film, ready for projection, in 40 sec from the start of processing. Print quality is comparable to that obtained in larger machines operating on a much longer processing cycle. The film is thoroughly washed and fixed, and has a sufficiently low hypo content for long-term or archival storage.

GENERAL DESCRIPTION

Front and rear views of the processor are shown in Figs. 1 and 2. The film is carried on reels in storage compartments in the side covers. Exposed film from the right storage compartment is processed as it passes through the console, and is taken up as finished film on a take-up reel in the left storage compartment. With different film routing through the storage compartments, film can be received from a camera film tunnel, or can be delivered directly to a projector. Switches are provided to control a camera and projector, starting or stopping them simultaneously with the processor film drive.

The film travels on spools through the three processing tanks shown in Fig. 3. Spray processing is used in all three tanks to avoid directional effects encountered in dip processing. These effects are caused by diffusion of development products from exposed film areas onto adjacent film areas that have had different exposure. With spray processing, a uniform solution concentration is delivered to all film areas, and development products are continuously removed. The solution penetrates deeply into the film emulsion. The exposed film passes first through the developing tank, then through the rinse and wash tank to the fix tank. The film then returns to the rinse and wash tank, from where it travels upward through the air squeegee into the drying chamber.

The air squeegee, in effect, scrubs the film with a stream of preheated air, bodily removing surface water. The film leaving the air

squeegee requires further drying, but has no surface droplets to spot the base or the emulsion. The film then passes through a drying chamber where infrared lamps and circulating air complete the drying process. After drying, the film is ready for waxing and projection.

The processing solutions, and the rinse and wash water, are used at a normal temperature of 120 F. The rinse and wash water is discarded after a single pass through the processor. The processing solutions are conserved through recirculation, and are replenished at a constant rate to maintain working strength. The spent solution residues mix with the rinse and wash water in the sump of the processor, where they neutralize each other almost completely and become sufficiently diluted for disposal in a sewage system.

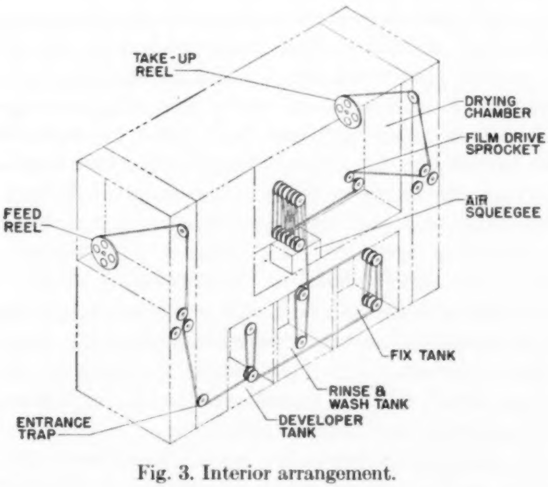

Fig. 3. Interior arrangement.

High solution temperatures and effective drying techniques reduce the total film processing time to 40 sec between the input and output ends of the processor. This time is divided as follows: develop, 5 sec; rinse, 2 sec; fix, 10 sec; wash, 5 sec; dry, 15 sec; and inter-process film transport, 3 sec.

The film drive sprocket (Fig. 3) is the only point in the processor where film is positively driven. The synchronous motor which drives the sprocket also drives the spindles which carry the upper film spools in the tanks and drying chamber. The spindles rotate at a higher rate than the film travel rate, and the resultant drag between the spindles and the spools assists the film in its travel through the

processor. This aided drive limits the film tension to less than 8 oz at any point.

In the tanks and drying chamber, the film travels in helical closed loops, with emulsion side out. Multiple loops stack compactly, so that a single group of wide angle sprays covers all the loops within a tank. The tanks are large enough for convenient film threading.

Intertank traps prevent spray transfer between tanks. The traps are plastic boxes with bottom drain holes, containing upper and lower rollers between which the film passes. The upper roller, being gravity loaded, rests on the film and confines the spray. An entrance trap seals the film tunnel against developer spray and wets the film uniformly at the start of development.

Controls for the developer system are grouped on the right side of the front panel, and are matched symmetrically by corresponding fix controls on the left side. The developer bottle, which holds 2½ gal of developer, is inverted into a stainless-steel reservoir at the top of the processor. An air trap bottle closure of the type used in chicken feeders maintains constant fluid level in the reservoir and seals the bottle against liquid spillage during insertion and removal. From the reservoir, the developer flows by gravity through a needle valve, which controls the replenisher flow rate, and through a flowmeter to the pump input line. The pump delivers filtered and heated developer to the spray nozzles in the developing tank. The spray, after impinging on the film loops, falls into the sump, where an overflow pipe maintains a constant level and continuously drains a portion of the spent solution. The remainder of the spent solution returns to the pump input, where it is replenished with fresh developer from the developer bottle and recirculated.

Two thermostatically controlled heaters maintain solution working temperature within a tolerance of ½ a degree. The first heater, a coarse heater with a high rating, functions on starting and cuts out at 5 F below the operating temperature. The second heater, a fine heater with a lower rating, cuts out when the solution reaches operating temperature.

The controls for the fix system are the same as those for the developer system. Normal replenisher flow rate for each system is 60 to 70 ml/min, or approximately 1 gal/hr. Two gallons are required for initial priming of each system. Approximately 0.9 gal/min are sprayed through each set of nozzles during operation.

The controls for the rinse and wash system are grouped in the center of the front panel. Operation of the system is entirely automatic. A thermostatic mixer, mounted on the front panel, maintains accurate

water temperature as long as the incoming hot water supply is hotter than the operating temperature. A panel thermometer indicates the hot water supply temperature and lights a warning light if necessary to indicate *Subnormal Water Supply*. The combined flow of hot and cold water supplies is 1½ gal/min.

The air squeegee housing contains two orifice blocks which direct air streams onto opposite sides of the film. The film enters the housing through a lower pair of rollers, spaced 0.008 in. apart, and leaves the housing through an upper pair of rollers, spaced 0.006 in. apart. Since the upper rollers provide no film clearance, the air stream is confined to the 0.001-in. clearance space under each lower roller. As a result, the air stream is in close contact with both sides of the film. The air stream bodily removes surface moisture from the film and carries it downward toward the sump. Each pair of rollers is spring loaded so that it yields to permit passage of a film splice, but does not deflect under normal air flow pressure. The housing may be opened for film threading.

Two 500-w infrared lamps heat the film in the drying chamber, driving moisture out of the film emulsion. An exhaust blower at the top of the drying chamber carries away moisture-laden air. Clean, dry air enters the console through filter panels in the side covers.

Delivery of Finished Film

Before the film leaves the drying chamber, it passes through a dip bath containing a solution of carnauba wax in carbon tetrachloride. It is generally recognized that films which have been waxed in this manner are more durable than unwaxed films. The film dries completely before it leaves the chamber, and the fumes are carried away by the exhaust blower. The film is then ready for projection.

As the finished film discharges from the processor it is either delivered to a projector or taken up on a storage reel within the side cover. One experimental type of side cover carries fittings for both methods of delivery. In addition to a take-up-reel spindle, it has a film storage elevator containing an isolating film loop. The maximum footage which can be stored in the loop is equivalent to 10 sec of running time. The main purpose of the loop is to permit simultaneous starting or stopping of processor and projector, allowing for a difference between the separate machine rates during the transition period.

A large-capacity film storage elevator is available which will permit as much as a 3-min delay between processor and projector. By use of this elevator, film can be monitored and edited prior to pro-

jection. The unit can be equipped with a commercial viewer, such as a Craig viewer, which has been found very useful for continuous monitoring.

PERFORMANCE RESULTS

A series of test runs has been made at different operating temperatures. The results of three of these runs are shown in Fig. 4, in the form of H & D curves. All runs were made with Eastman Fine Grain Release Positive Film Type 7302, processed in D-8 developer. At a temperature of 120 F, the temperature at which the required increase in processing rate was obtained, a density of 3 is attained within the linear portion of the curve.

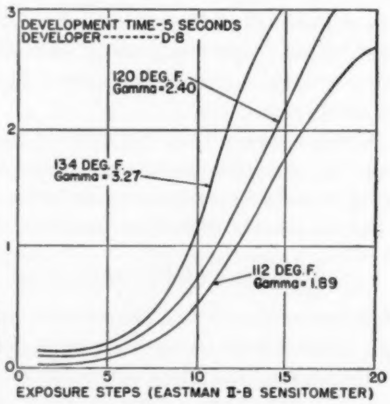

Fig. 4. Density vs. exposure at different temperatures.

It may be noted that the upper temperature limit of the series of runs exceeds the allowable processing temperature of the film. The purpose of these runs, however, was to determine the range of gamma variation in processing at different temperatures. The curve reproduced in Fig. 5 shows a very linear variation with temperature, demonstrating the practicability of gamma control through temperature setting.

The residual hypo content of film processed at normal temperature (120 F) was tested by the mercuric chloride method described in American Standard Specifications Z38.3.2–1945 "Films for Permanent Records." The film samples for test were taken at random from several film batches, and were split into two groups. The samples of one group were washed thoroughly in carbon tetrachloride to re-

move the lubricating coating or carnauba wax; the samples in the other group were untreated. All samples in both groups showed a sufficiently low hypo content to be well within the acceptable limit. On the basis of hypo content, the film qualifies satisfactorily for use in permanent records.

APPLICATIONS

The fact that finished film can be reviewed within a minute after the event has been photographed is possibly the most valuable single characteristic of the processor.

In motion picture studio practice, special sets must often be retained intact until the film has been processed and reviewed. The

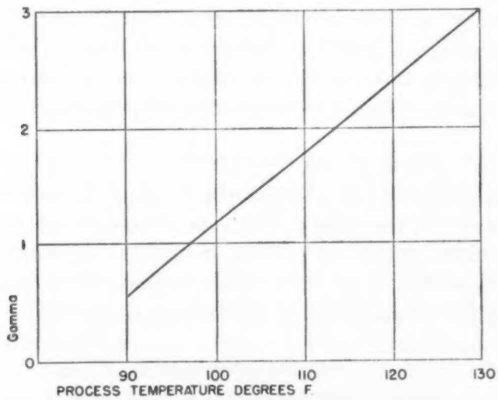

Fig. 5. Gamma variation with temperature.

necessity for checking unusual lighting effects may keep actors and stage hands on location for a much longer time than required for photography alone. Delays of this nature can be minimized by using an auxiliary 16-mm camera in conjunction with a rapid film processor.

Motion picture theaters may now photograph and process their own 16-mm film. This opens a potentially tremendous new field of application, the possibilities of which have not been fully explored. A 16-mm arc lamp projector is available for theater exhibition of films which have been prepared in this manner.

The processor is expected to become a useful tool for industrial laboratories. Machinery studies are often recorded photographically on motion picture film, but the results are not available until the film has been processed. The delay entailed in commercial processing

extends the time of a test program and increases the cost. The rapid film processor, on the other hand, can be used to make permanently recorded results almost immediately available. No major loss of time and chemicals is involved in starting and stopping the machine, and since threading is a relatively simple operation, small discontinuous film batches are readily handled. The processor is therefore well suited for laboratory operation. It is believed that use of the processor will enable sizeable economies to be effected during the course of a test program.

Films which are prepared for television broadcast by the medium of video recording require very close control in all phases of preparation. The contrast and density of the finished print are of utmost importance. When the station equipment includes a rapid film processor the studio crew can control all phases of photography, including the recording, processing, and reproduction of the film. Factors affecting either contrast or density can be partially or completely corrected within the studio, before the film enters the projector.

CONCLUSION

The rapid film processor is sufficiently compact for general use in projection booths. It provides continuous automatic operation and enables convenient control of process variables. As indicated by the performance results, it produces film of adequate contrast, density and permanence to meet critical studio requirements.

ACKNOWLEDGMENT

A development of this nature represents the combined work of many individuals. The authors wish to express to the following their appreciation for technical engineering data: H. E. White and E. Warnecke of Eastman Kodak Co. and J. G. Stott, formerly of Eastman Kodak Co. and now of Du-Art Film Laboratories.

A Method of Measuring Electrification Of Motion Picture Film Applied to Cleaning Operations

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SUMMARY: A dielectric, such as photographic film, becomes electrified when rubbed or passed over rollers. The electrostatic charges which are generated attract dust and dirt particles to the film. Since dirt is objectionable to both the manufacturer and the user of film, means are sought to reduce electrification. This paper describes a method that has been devised to evaluate roller-film combinations electrostatically. Film is brought to a given potential, either positive or negative, and the change in potential measured as it passes over a test roller. Typical data for a variety of rollers are presented. The work was extended to test the effect of rubbing film with cleaning pads of velvet and mouton fur. Measurements were also made with solvents applied to a velvet cleaning pad.

A dielectric material, such as photographic film base, becomes electrified when rubbed against almost any object, or when it passes over a roller, either of dielectric or of metallic composition. One of the effects of this electrification, and one which causes a great deal of trouble, is the electrostatic attraction of dust particles to the film. An attempt to clean the film by brushing or rubbing usually results in higher charges which further increase the difficulty of removing the dust. This problem is serious to the manufacturer of the support who seeks to produce a dust-free film, and to the laboratory technician who handles processed films, particularly when there is dust on negative film in the printing process. If emulsion-coated films become electrified beyond a critical value, discharges occur and fog and other markings are produced.

In the handling of photographic products, one aim is to select materials and to design equipment which will produce a minimum amount of electrification. Naturally, some means of evaluating these materials in contact with different types of photographic films is necessary. This is true also in the selection of the cleaning materials and the methods of their use. The purpose of this paper is to describe a method for determining the electrification properties of roller-film combinations. In addition, it will be shown how the method can be

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adapted to measure the charging and discharging characteristics of cleaning pads and the influence of cleaning solutions applied to these pads.

TESTING PROCEDURE

The schematic arrangement of equipment used in comparing various roller-film combinations is shown in Fig. 1. A loop of film, about 30 ft in length, is driven over the various rollers (r_1, r_2, r_3, r_4, r_5, r_6, r_7) and the test roller, in the direction shown by the arrows. Rollers r_1 and r_2 are insulated to reduce conduction of charge in the film from the test roller to the ground. The film is driven at a constant velocity by a synchronous motor connected to roller r_5. The film is kept under constant tension by attaching a weight, W, to a floating roller, r_7.

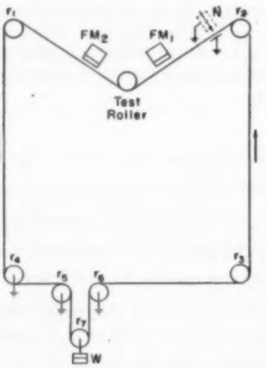

Fig. 1. Schematic diagram of testing apparatus.

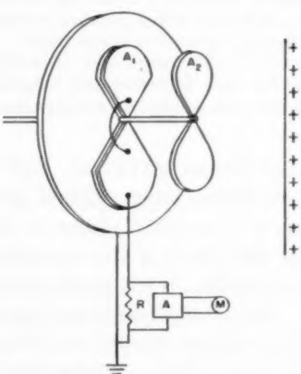

Fig. 2. Schematic diagram of field meter.

This insures a uniform pressure of the film against the test roller. The film is first brought into equilibrium with a given humidity and temperature, and then tested in this same atmosphere. The angle of wrap of the film at the test roller is normally kept at 60 deg.

After leaving roller r_2, the film passes between an insulated needle, N, and a grounded plate. By raising the needle to high potentials, either positive or negative, charges of either polarity may be sprayed onto the film. This is similar to the scheme that is used in charging the belt in the Van der Graaf type of electrostatic generator. A 20-kv, d-c power supply, in which either the positive or the negative terminal may be grounded, is used to supply the needle potential. The grounded plate concentrates the field and increases the efficiency of this charging process. A shield is placed around the needle to prevent stray fields from affecting near-by electronic equipment.

An electric field-meter, FM_1 (Fig. 1), is placed just ahead of the test roller and a similar unit, FM_2, just following it. These instruments are of the type described by Gunn[1] and Waddel.[2] A drawing of the detecting unit of this instrument is shown in Fig. 2. A grounded two-bladed sector, A_2, rotates in front of an insulated stationary sector, A_1; A_1 is alternately exposed to, and shielded from, the electrified plane at the right of the figure, which, in this case, is shown to be charged positively. The insulated sector is connected to ground through a high resistance, R. When exposed to the field, a charge is induced on A_1; when A_1 is shielded from the field, the induced charge flows back to ground through R. Rotation of the sector, A_2, repeats this process

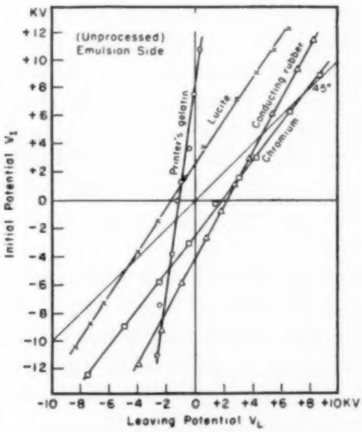

Fig. 3. Curves showing electrification of different film-roller combinations.

whereby an alternating potential is developed across R. This potential is amplified by the amplifier, A, and read on the output meter, M.

In practice, a 10-bladed sector is rotated at a speed of 1,800 rpm. This produces a 300-cycle signal. With an amplifier which is peaked for this frequency, 60-cycle disturbances are sufficiently excluded so that an electronic rectifier can be substituted for the mechanical rectifier system which has been more commonly used.[3] With this instrument, the electric field, due to the charges on the film, can be read. The field meters are calibrated in terms of volts on a uniformly charged plate placed in the same position as the film to be measured. By using two of these instruments, the potentials which a given area of film assumes before and after passage over the test roller can be read di-

rectly. The relation between these two sets of values can be used to specify the electrostatic characteristic of a given roller-film combination.

The data are plotted on a 4-quadrant type of graph, with the leaving potential, V_L, as a function of the initial potential, V_I. The film is brought to any initial potential, V_I, with the necessary needle potential. The initial potentials, V_I, are plotted as ordinates, with the zero level in the center of the chart-positive potentials above the zero line, and the negative potentials below. The leaving potentials, V_L, are plotted as abscissae in a similar manner, with positive potentials to the right, and negative to the left of the zero line. If the data fall on the 45-deg line drawn diagonally through two of the quadrants (Fig. 3), the original voltage level of the film has not been altered in passing over the test roller. In the upper right-hand quadrant, if the curve falls to the left of the 45-deg line, the film is being discharged; if to the right, it is being charged. Similarly, in the lower left-hand quadrant, film will be discharged if the curve is to the right of the 45-deg line, and charged if at the left of this line.

Roller Data

Examples of running unprocessed Eastman Fine-Grain Release Positive Film over four types of rollers are shown in Fig. 3. The emulsion side of the film contacted the rollers. A chromium-plated metal roller or a conducting rubber roller will reduce negative potentials on the film, but will add potential to the film if it is at low positive potential. The resulting value for subsequent passages may be found by applying V_L for one passage to V_I of a subsequent passage. By this procedure, it may be seen that the film must ultimately come to the potential which corresponds to the intersection point of the curve and the 45-deg line, e.g., for the metal roller this value is +7.5 kv and for the conducting rubber roller +4.5 kv.

An example will illustrate. Referring to the conducting rubber roller curve, if we start with an initial potential, V_I, equal to about −4 kv, the charges will be completely removed, and the leaving potential, $V_L = 0$. Now, taking zero on the V_I axis, the V_L value on the conducting rubber curve is +2.2 kv. Repeating this, if we apply $V_I =$ +2.2 kv to the conducting rubber curve, we get $V_L =$ +3.0 kv. Continuing this process, subsequent values are, in turn, +3.5 kv, +3.8 kv, etc., and finally the curve intersects the 45-deg line at about +4.5 kv. No further change in potential will take place. The film now leaves the test roller at the same potential it had when it reached the

test roller. This process corresponds to the passage of the film over a number of rollers of this same material.

Examination of the Lucite roller curve shows that for the film used in this case, a high positive potential, V_I, is always reduced by passage over the roller until the incoming potential, V_I, becomes about +2.5 kv. In the next passage over this roller or a duplicate roller, negative charges are added and the film leaves with a potential of −1.5 kv. Continuing the step-by-step process, the film reaches a stable potential level of approximately −4.5 kv, again the point of intersection with the 45-deg line. In the case of the printer's gelatin roller, if film, charged either positively or negatively, contacts this roller, it will be brought to a level of about −1 kv. This occurs in a very few roller passages because of the steepness of the curve. Numerous types of curves are found with different roller-film combinations and, in many cases, quite different data are found on the support side from those on the emulsion side.

Cleaning Pads and Solutions

In order to test the effect of rubbing film with a cleaning pad, a 2-in.-diameter roller was covered with the test material, and the film passed over the material on the roller with a 60-deg wrap, the roller being held stationary. The same technique of measurement as described above was used.

It is found that ordinary velvet produces very little electrical charging when rubbed against either the emulsion or the support side of Eastman Plus-X Panchromatic Negative (processed) Film. The curves lie very close to the 45-deg line (Fig. 4), showing that this film may pass across the velvet at any potential and its potential level will not be altered. This may, therefore, be termed a "neutral" combination.

Mouton fur, on the other hand, alters considerably the potential level of processed motion picture negative film (see Fig. 5). In contact with the emulsion side, mouton fur discharges the film when it is charged to either positive or negative values, with the exception of positive potentials under 2 kv. With this exception, the film will always leave the fur at a lower potential than it possessed upon reaching the fur. Low positive potentials will be increased but will not exceed a 2-kv level. This corresponds to the point of intersection with the 45-deg line. The mouton fur will discharge the support side very rapidly when charged positively. Between +4.5 kv and zero, the polarity is reversed by the fur, and for all approaching negative potentials, still higher negative values result. Successive passages

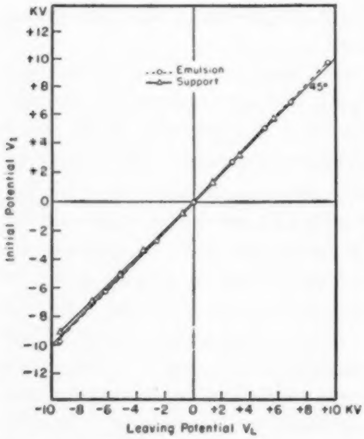

Fig. 4. Electrification curves of dry velvet and processed motion picture negative film.

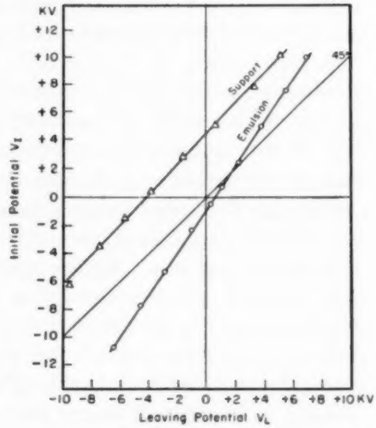

Fig. 5. Electrification curves of mouton fur and processed motion picture negative film.

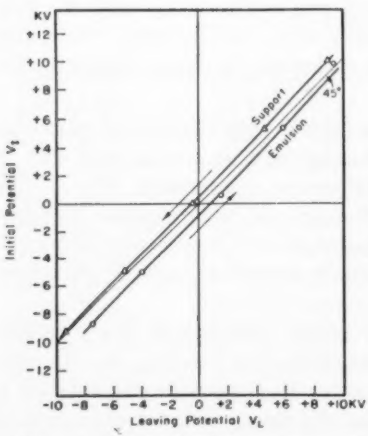

Fig. 6. Electrification curves of velvet plus petroleum ether and processed motion picture negative film.

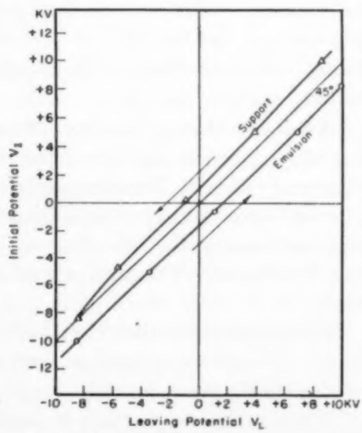

Fig. 7. Electrification curves of velvet plus Skelly Light Solvent and processed motion picture negative film.

will, therefore, build up very high potentials, since the curve does not intersect the 45-deg line, at least up to -6 kv, the limit used here. The point corresponding to $V_I = 0$ is of significance since it predicts the resulting potential with uncharged film, i.e., at zero level. A low

positive charge equivalent to 0.5 kv will be imparted to the emulsion side, and a *negative* charge equivalent to 4 kv to the support side.

If the velvet is wetted with petroleum ether and rubbed against the emulsion side of processed motion picture negative film, it will decrease the potential of negatively charged film but will raise the potential of positively charged film (see Fig. 6). On the support side, the reverse is true, viz., positive potentials are reduced, and negative potentials increased. These may be termed "positive" and "negative" combinations, respectively, since on the emulsion side, potentials move in the direction of positive values, and on the support in the negative direction, as shown by the arrows in Fig. 6.

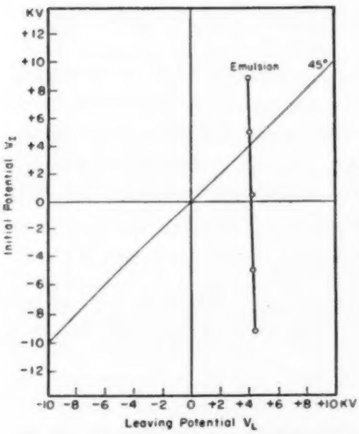

Fig. 8. Electrification curve of velvet plus carbon tetrachloride and the emulsion side of processed motion picture negative film.

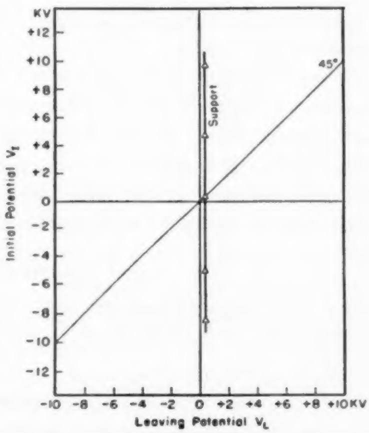

Fig. 9. Electrification curve of velvet plus carbon tetrachloride and the support side of processed motion picture negative film.

Velvet wetted with Skelly Light Solvent (a petroleum ether product manufactured by the Skelly Oil Co.) gives practically the same results on both the emulsion and support sides as described above for velvet and petroleum ether (see Fig. 7). If velvet saturated with carbon tetrachloride rubs the emulsion side, it will maintain the potential of the film at a constant value of +4.5 kv, regardless of the initial magnitude or polarity of the film potential. This is shown by the vertical lines in Fig. 8. It might be termed a "positive regulator."

A similar phenomenon occurs when the support side is rubbed with velvet saturated with carbon tetrachloride (see Fig. 9). The regu-

lated potential is also positive but has a much lower value, +0.4 kv. This represents the closest to the ideal found in any of the combinations tested, in that nearly complete de-electrification of the film is accomplished. If film can be kept at low potentials of this order of magnitude, there should be little tendency for it to collect or hold dirt because of electrostatic charges.

CONCLUSIONS

The electrification behavior of film, when passed over a roller or rubbed with a cleaning pad, can be satisfactorily evaluated by bringing the film to given potentials, either positive or negative, and noting the change in the potential level after passing the test material. Most rollers of the more common materials which are suitable for use with motion picture films add charge to film rather than dissipate any existing charge.

Dry velvet does not appreciably change the potential of processed Eastman Plus-X Negative Film when rubbing either the emulsion or the support side. If velvet can be kept wetted with carbon tetrachloride, it will hold this film at about +4.5 kv when rubbed against the emulsion side, or it will almost completely discharge the film when rubbed against the support side.

ACKNOWLEDGMENTS

The author is greatly indebted to R. Hubbard and T. Whitmore, for their assistance in this work, and to Dr. J. H. Webb, under whose direction this work was carried out.

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Variable-Area Sound Track Requirements for Reduction Printing Onto Kodachrome

By ROBERT V. McKIE

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SUMMARY: This paper presents a plan for establishing the processing control of variable-area sound tracks printed on Kodachrome. Data are presented for two methods starting with the 35-mm master or dubbing print and following through the intermediate steps to the final Kodachrome prints.

The increased activity in the Kodachrome field has made it necessary to establish commercial processing tolerances. The processing control of variable-area tracks in general has been successfully established by the cross modulation method, and this same method was adopted to establish the processing tolerances for variable-area tracks on Kodachrome. There have been published a number of articles[1–4] on the processing control of variable-area sound tracks. All of these deal with the fundamental problem of controlling the image spread in the final print so that its average transmission will be constant regardless of the amplitude or frequency recorded on the track, provided that noise reduction is not considered. In the negative print process for black-and-white tracks this becomes a simple process of producing enough image spread in the negative to balance or cancel out the image spread in the print. It is understood, of course, that the print density is maintained high enough to give a good output level and signal-to-noise ratio. Kodachrome is a reversal process and this introduces other problems. The Kodachrome sound track must be printed from a positive rather than a negative and the finished sound track is a silver sulfide rather than a metallic silver track. The exposed Kodachrome duplicates are developed in a normal black-and-white developer and the exposed silver bromide area is converted to metallic silver. The unexposed silver bromide is unaffected during this process. The sound track is then treated in a sulfide solution which converts the unexposed silver

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bromide to silver sulfide. In the final processing step the metallic silver is removed and the portion of the Kodachrome track exposed in the printer becomes the transparent area of the Kodachrome print. The sound track remains as a positive image of silver sulfide. To prevent a serious loss of level, there must be sufficient exposure during the printing operation to maintain the clear area portion of the completed Kodachrome print relatively transparent. As shown in the following data this area becomes the controlling density. It is also necessary to control the image spread of the black-and-white printing master so as to cancel the image spread resulting from the Kodachrome printing operation.

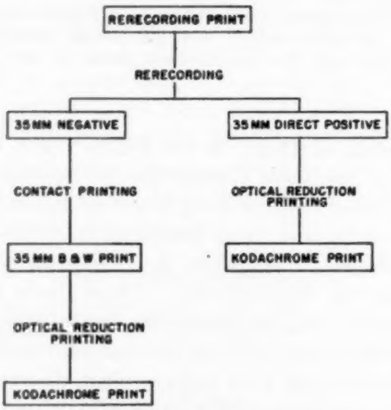

Fig. 1. Methods for making Kodachrome sound tracks.

A series of tests was planned to determine a practical method of establishing the processing control of printing variable-area tracks on Kodachrome. The following data are presented as examples of this control. Standard printers and developers were used in making this series of tests. The negatives and prints were processed according to the routine practice of the commercial laboratories printing Kodachrome duplicates.

TEST PROCEDURES

Figure 1 shows the two methods most generally used for producing Kodachrome variable-area sound tracks by optical reduction printing. These methods will be discussed in the order shown.

Method A

A 35-mm cross modulation test negative was recorded at 80% amplitude. This test consisted of: (1) 400 cycles for reference level; (2) 4000 cycles for measuring high-frequency loss; and (3) 4000 cycles modulated in amplitude at a 400-cycle rate for cross modulation measurements.

Using Eastman fine grain sound recording film, Type 1372, the cross modulation test was exposed with a 3-mm 597 filter for a density of 2.70. This negative density value was determined from previous cross modulation tests for black-and-white printing. The negative was then developed in a high contrast variable-area negative developer at a gamma of 3.50. Previous tests had indicated that no advantages could be gained by varying the density of the original negative.

From the 35-mm negative a family of contact prints was exposed with unfiltered light onto Eastman fine grain release positive, Type 1302. The black-and-white prints were developed in a print type developer at a normal release print gamma of 2.50. Print densities ranging from 1.28 to 2.25 were obtained.

Figure 2 shows the cross modulation curve of the black-and-white prints that were used for making the Kodachrome duplicates. A normal release print at balance density (1.28), a balance density being the maximum cancellation point, and four other prints with increasing degrees of image spread as indicated by this cross modulation curve, were selected for making the Kodachrome prints. A lighter than balance density offered no advantages for Kodachrome printing.

A family of black-and-white prints developed in a variable-area high contrast negative developer indicated that extremely high black-and-white positive densities on the order of 3.5 would be required for Kodachrome printing. As these high densities were often difficult to obtain and control under existing commercial printing conditions, only a print type developer was used for the final tests.

Families of Kodachrome duplicates were then made by optical reduction printing from these 35-mm black-and-white prints. The Kodachrome film was processed at the Eastman Kodak Cine Processing Plant in Hollywood in the normal manner for sound duplicates.

The densities of the negatives, black-and-white positives, and Kodachrome prints were measured with the Western Electric RA1100B densitometer using the visual filter. The Kodachrome prints covered a clear-area density range from 0.55 to 0.90. The Kodachrome prints are designated by the clear-area density rather than the sound track density. Due to the characteristics of the duplicating film, we have

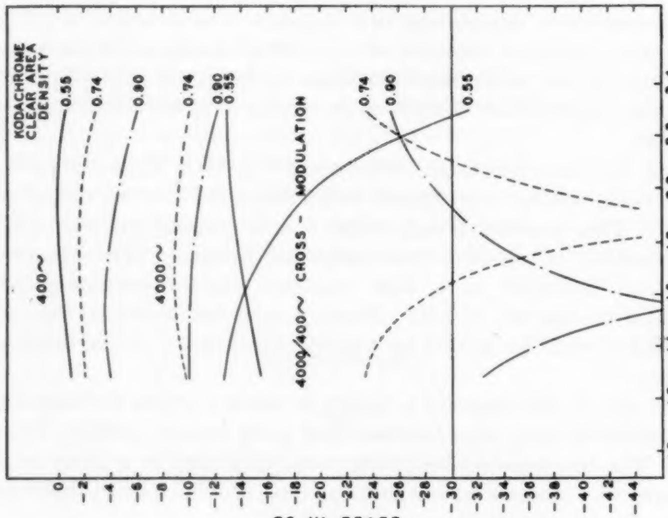

Fig. 3. Kodachrome processing characteristics.

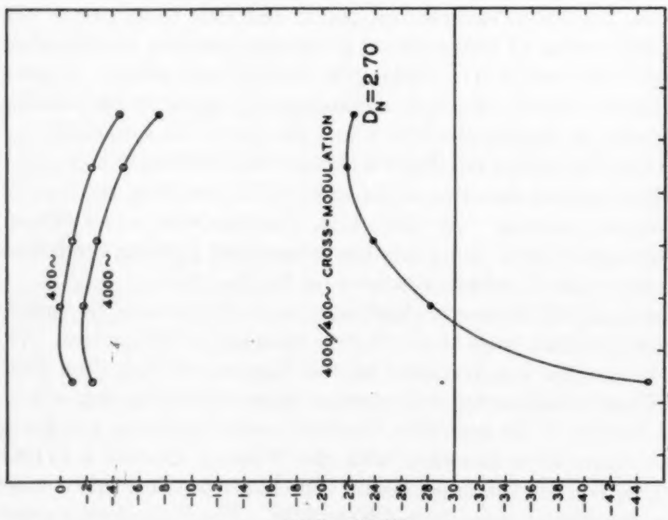

Fig. 2. Characteristics of black-and-white printing masters.

found that the clear-area density is the best index of the image spread present in the Kodachrome sound track and therefore the most accurate means of measuring density for control purposes.

The cross modulation tests were run on an RCA 200 16-mm reproducer through a calibrated reproducing system. The reproducer was calibrated with the SMPE multi-frequency 16-mm test film Series 555.

Figure 3 shows cross modulation curves plotted against the black-and-white print density.

It has been established by numerous tests that −30-db cancellation of the 400-cycle component in the cross modulation test is satisfactory for all types of material; therefore density tolerances have been established at this cancellation value.

From these curves it is evident that satisfactory cancellation may be obtained from black-and-white sound tracks having a wide range of densities. However, volume level, as shown by the 400-cycle curve, and high-frequency attenuation, as shown by the 4000-cycle curve, must also be considered. Therefore, the Kodachrome prints which most closely satisfy all the conditions of volume output, high-frequency response and cancellation would be a clear area density of 0.74 printed from a black-and-white positive having a density of 1.85. A lighter Kodachrome print density would require a darker printing master for sufficient cancellation with a resulting loss in high frequencies, as shown by the 4000-cycle curve of the 0.55 print density. A darker Kodachrome print density would result in loss of level as shown by the 400-cycle curve of the 0.90 print density.

Method B

Using Eastman fine grain sound recording film, Type 1372, a direct positive cross modulation test was exposed with a 3-mm 597 filter over a density range from 1.60 to 2.30. The direct positive was developed in a print-type developer at a normal release print gamma of 2.50.

Figure 4 shows the cross modulation curve of the EK 1372 direct positive that was used for printing a family of Kodachrome duplicates.

Kodachrome prints covering a density range from 0.59 to 0.90 were made by optical reduction printing from the 35-mm direct positives. The Kodachrome film was processed at the Eastman Kodak Cine Processing Plant in Hollywood in the normal manner for sound duplicates.

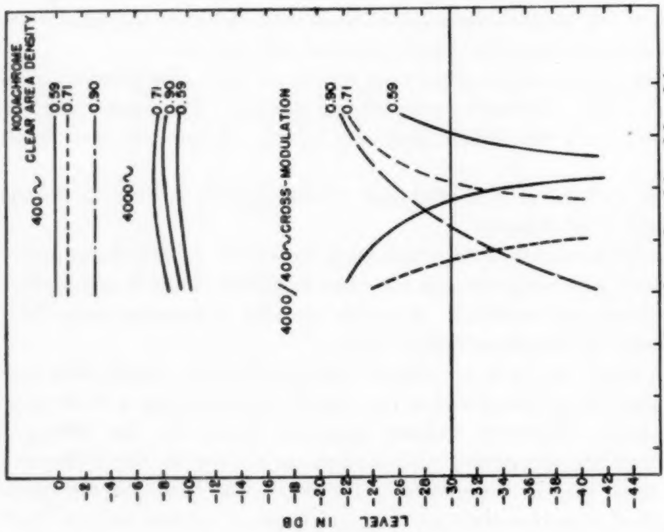

Fig. 5. Kodachrome processing characteristics.

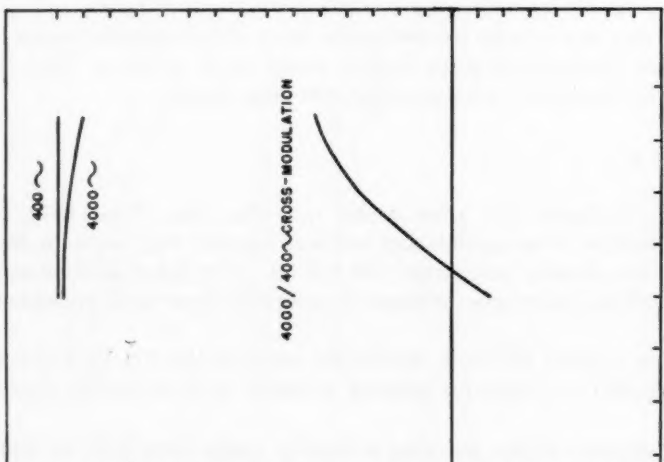

Fig. 4. Characteristics of black-and-white direct positives.

These prints were measured in the same manner as the Kodachrome duplicates made under Method A.

Figure 5 shows the cross modulation curves plotted against the direct positive density.

The Kodachrome print which most closely satisfies the conditions of volume output, high-frequency response and cancellation would be a clear area density of 0.71 printed from a direct positive having a density of 1.88. The cross modulation test processed under these conditions also indicates that a lighter Kodachrome print density would require a darker direct positive density for sufficient cancellation with a resulting loss in high frequencies as shown by the 4000-curve of the 0.59 print density. A darker Kodachrome print would result in a loss of level as shown by the 400-cycle curve of the 0.90 Kodachrome print density.

For those studios not equipped to make cross modulation measurements, the proper combination of black-and-white and Kodachrome print densities can be determined by listening tests. If Method A is to be used, a short section of sibilant dialog should be recorded and developed to a normal negative density. A series of black-and-white prints made from this negative and covering a wide density range can be used for printing a family of Kodachrome duplicates. The Kodachrome prints should then be run on a good reproducer to determine which combination of negative and print density gives the best quality. Improper density combinations will cause the sibilants to be distorted or rough. Therefore, the print which is free of sibilant distortion, which has the best volume output and high-frequency response together with low surface noise, will determine the proper combination of black-and-white and Kodachrome print density to be used.

When printing from a direct positive the same procedure should be followed. The direct positive sibilant tests should be exposed over a wide density range and developed at a normal release print gamma. A family of Kodachrome prints made from the direct positives can then be run on a good reproducer to determine which combination of direct positive density and Kodachrome print density gives the best quality.

CONCLUSION

From the above tests it is evident that satisfactory sound quality on variable area Kodachrome prints may be obtained by selecting that printing exposure which will produce a clear area density giving satisfactory volume level and high-frequency response and by using a

black-and-white with sufficient image spread to cancel the image spread which will be produced in the Kodachrome printing operation.

From these tests the following values were found to produce the best sound quality for 16-mm duplicates made by optical reduction printing:

For Method A

(1) Negative exposed for a density of 2.70 and developed in a high contrast negative developer.
(2) 35-mm black-and-white print exposed for a density of 1.85 and developed in a print-type developer at a normal release print gamma.
(3) Kodachrome prints exposed for a clear area density of 0.74.

For Method B

(1) 35-mm direct positive exposed for a density of 1.88 and developed in a print-type developer at a normal release print gamma.
(2) Kodachrome print exposed for a clear area density of 0.71.

Due to variations in printers and developers, it is impossible to give absolute densities for the black-and-white printing masters to be used for making Kodachrome sound tracks. Therefore, data in this paper will apply to only one particular set of printing and processing conditions and can serve merely as a guide in helping to establish density tolerances for other printing or developing conditions that will be used.

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The Pressurized Ballistics Range At the Naval Ordnance Laboratory

By L. P. GIESELER

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SUMMARY: A description is given of the ballistics range at the Naval Ordnance Laboratory, White Oak, Md. Details of the 25 photographic stations with their electronic controls are included.

A ballistics range is a piece of equipment used for determining the characteristics of a missile in flight. In its operation it is very similar to a classic experiment done by Leland Stanford and Edward Muybridge in 1872. Stanford, a wealthy sportsman, was interested in finding out information about the various gaits of the horse. He engaged Muybridge to set up a group of 30 cameras in a row, in a special building about 50 ft long. The shutters of the cameras were controlled electrically by wires stretched transversely from the cameras to a white wall on the opposite side. A horse galloping by touched the wires, and a series of pictures of the action were thus obtained. A chronograph measured the time intervals between successive pictures.

If we use high-speed flash photography for the cameras, and substitute electronic methods for the shutter mechanism, we will have a modern ballistics range.

Figures 1 and 2 show the physical layout of the pressurized range at the Naval Ordnance Laboratory. The range is located in a steel tube 3 ft in diameter and over 300 ft long. Pressures up to five atmospheres and down to one-hundredth of an atmosphere can be obtained inside the tube. A standard 20-mm gun located in one end shoots the projectiles down the length of the tube into an 8-ft long barrier of sand. Smaller caliber guns can also be used. Twenty-five photographic stations are located along the tube.

Figure 3 is a close-up of one of the photographic stations. When the missile passes between the source of light at A and a photocell located in B, a chain of events is initiated which ultimately causes the micro-second spark source, C, to flash. A shadow of the missile is thus thrown on the vertical photographic plate, D, and also by reflection from a mirror, E, to the horizontal plate, F. A set of

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accurately located grooves from which the exact position of the missile can be determined is also photographed.

Figure 4 shows the components required for one photographic station. These components will be briefly described in the following paragraphs.

Light-Screen Source

This is a type T12-1 lamp manufactured for this purpose by the General Electric Co. The filament is approximately 28 in. long and is equipped with a spring tension device which holds it taut and straight at all times. The lamp is enclosed in a housing containing a slot covered with Eastman ruby safelight material. This reduces to a low value any fogging of the photographic plates caused by the light-screen source.

Photocell Amplifier

The photocell amplifier is made up of a photocell, a three-stage amplifier, a thyratron and a power supply. The photocell is of the

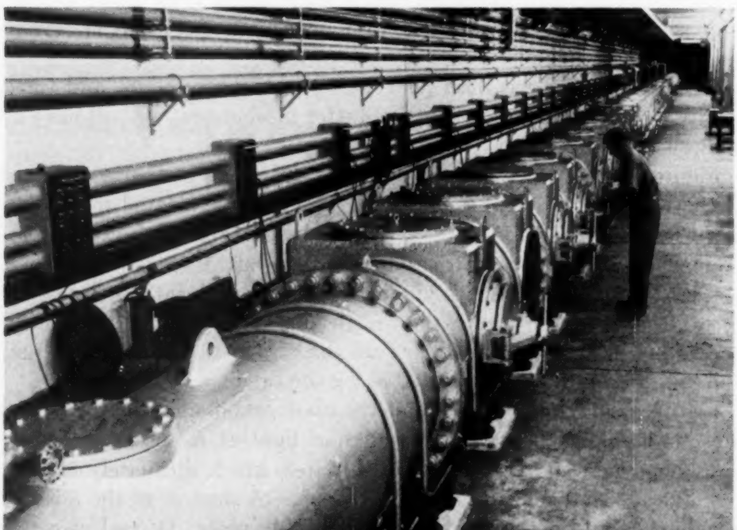

Fig. 1. Pressurized range, as seen from the gun end.

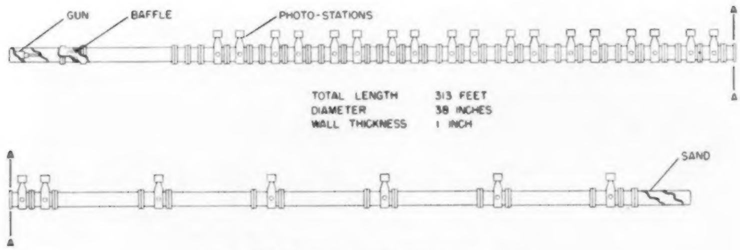

Fig. 2. Pressurized ballistics range.

high vacuum type with a red-sensitive photosurface. Light from the light-screen source is focused on this surface by a plastic cylindrical lens, which also serves to reduce the effect on the photocell of extraneous light coming from other directions. A gain control applies selective negative feedback to the amplifier and makes it possible to adjust the gain to the size of missile to be photographed. Because of the conditions of vacuum and pressure under which the apparatus is to be used, the paper condensers are of the hermetically sealed type, and no electrolytic condensers are used at all.

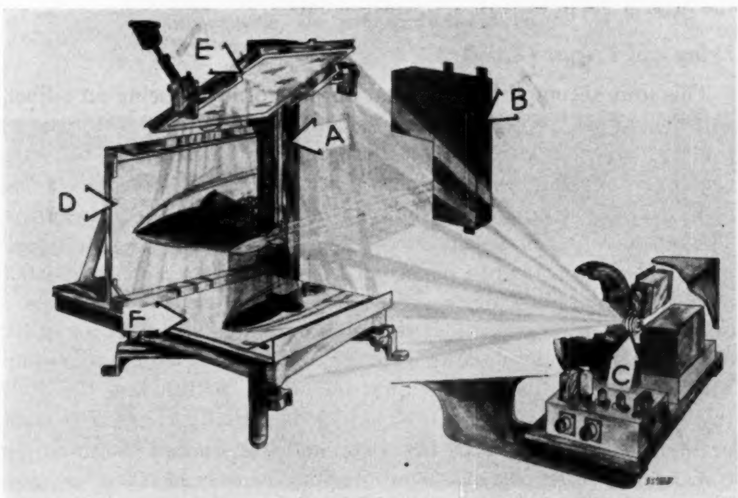

Fig. 3. Perspective view of one photographic station.

A, light-screen source	C, spark	E, mirror
B, photocell amplifier	D, vertical plate	F, horizontal plate

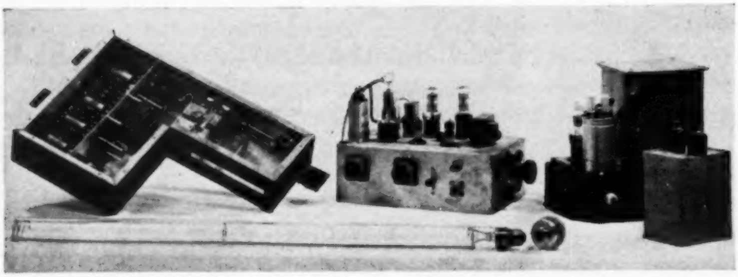

Fig. 4. Components required for one photographic station: foreground, General Electric Co. Type T12-1 Lamp and microsecond spark; background (from left to right), photocell amplifier, delay and trigger unit, high-voltage power supply and main discharge condenser.

With 70 volts applied to the light-screen source, the photocell current will be constant at approximately 0.5 microamperes, and no signal will be transmitted through the input condenser to the amplifier. A rapid change in light intensity such as is caused by a missile passing between the light-screen source and the photocell will originate a signal which ultimately fires the thyratron. An output pulse of about 50 v magnitude will result, and this value is independent of the magnitude of the initial optical signal.

Delay and Trigger Circuit

This unit accomplishes the dual purpose of introducing an adjustable delay in the sequence of events, and producing a 12,000-v trigger pulse which initiates the spark discharge. It consists of a 6J6 tube used in a "one-shot" multi-vibrator circuit, a 2D21 "booster" thyratron, a 3C45 output thyratron, and an output step-up transformer. The output of the first tube consists of a single negative rectangular wave whose duration can be varied from 70 to approximately 10,000 μsec. The coupling network to the 2D21 thyratron produces a differentiating action, which changes the above signal to an initial negative pulse, followed after an adjustable interval by a positive one. The positive pulse fires the thyratron, which in turn fires the 3C45 thyratron. A 0.5-μf condenser, which is initially charged to 1200 v, discharges through both thyratron and the primary of the output transformer, producing an output of approximately 12,000 v.

Spark and Discharge Circuits

The output pulse of the delay unit is applied between a trigger electrode and one of the main electrodes of the spark. The ions

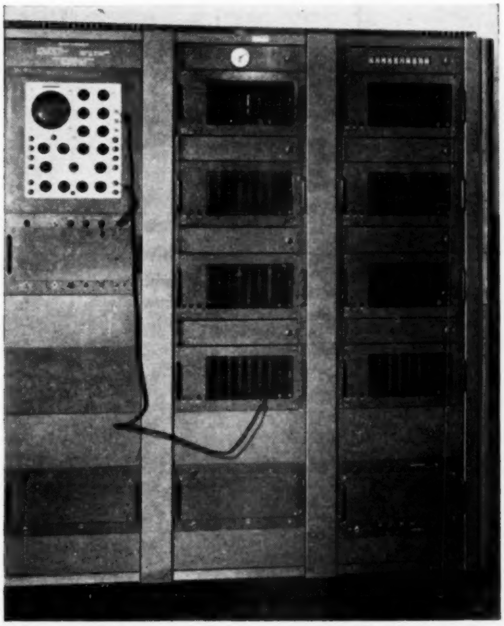

Fig. 5. Electronic chronograph; seven standard counters and one test counter are available; the oscilloscope is used for trouble shooting.

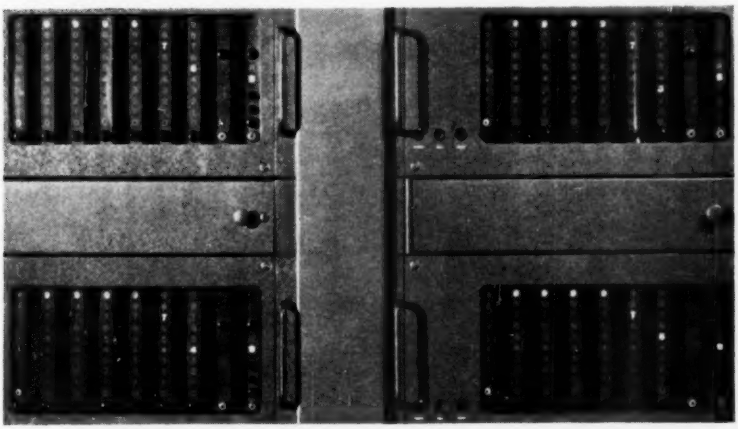

Fig. 6. Close-up of four of the counters; an interval of approximately 0.1 sec has just been measured by the counters connected in parallel.

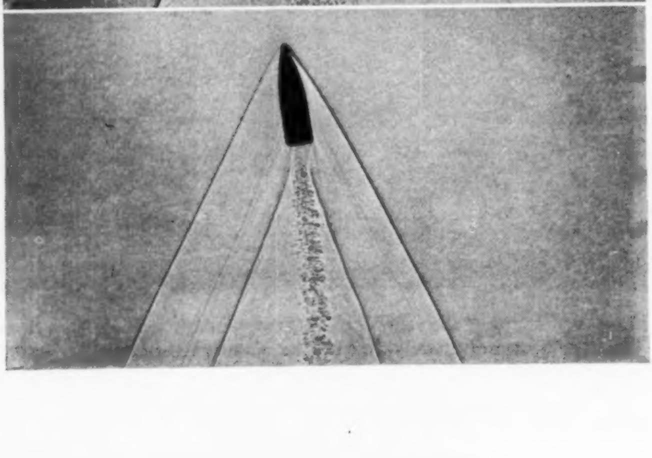

Fig. 7. 30-Caliber bullet at 25-psi pressure.

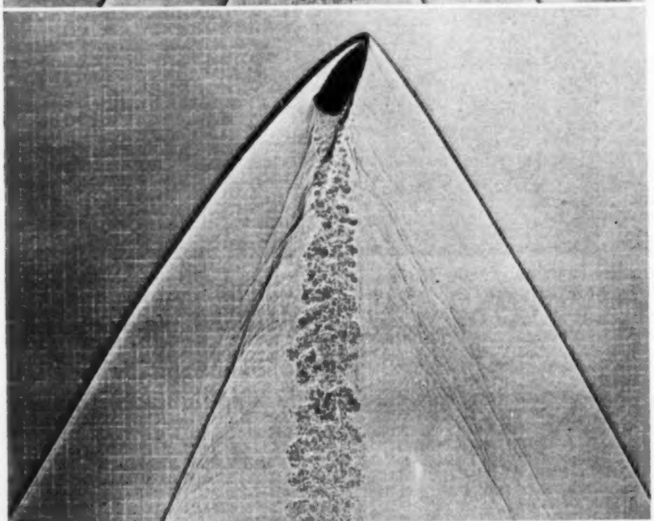

Fig. 8. 30-Caliber bullet at 50-psi pressure.

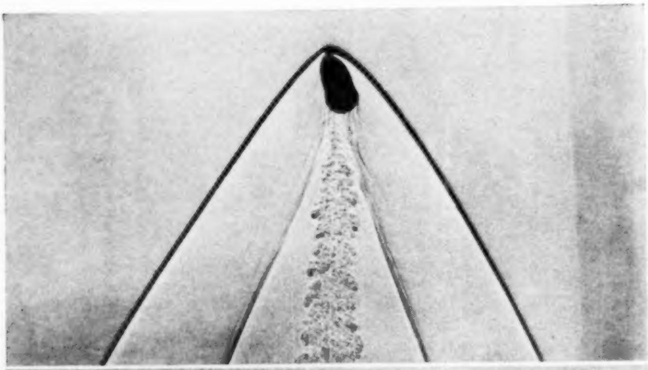

Fig. 9. 30-Caliber bullet at 75-psi pressure.

formed cause the breakdown of the main gap, thereby discharging a 0.4-μf main discharge condenser, and producing a short brilliant flash of small diameter. The effective duration is approximately 0.5 μsec, and the intensity is sufficient to give pictures of good contrast at a distance of 72 in. At the instant that the spark flashes, a pulse is produced which actuates the chronograph.

Further Considerations

Lantern slide plates are used rather than film or paper to eliminate errors in missile position that might be caused by shrinkage. They may be either 11 $\times$ 14 in. or 14 $\times$ 17 in. in size. The large size is convenient for showing a large part of the shock wave and the turbulent wake. The developing is done in 80-gal stainless-steel tanks that will accommodate up to 48 plates at one time. Figure 5 is a photo graph of the electronic chronograph used to measure the time required for the missile to pass from a reference station to any other station. Intervals up to 1 sec may be obtained to a measuring accuracy of 0.0000001 sec. The absolute accuracy is somewhat less, being determined by a quartz-crystal oscillator which drives all seven counters. Figure 6 shows how four of the counters look after they have measured an interval of approximately 0.1 sec produced by the test counter. The four determinations of the interval read 0.0999975, 0.0999973, 0.0999974, and 0.0999975 sec. Figures 7–9 are actual photographs of a 30-caliber bullet at various pressures.

To explain the value of the pressurized feature of the range, it is necessary to discuss briefly some aerodynamic considerations. Most ranges and wind tunnels obtain information on small models rather than on the full-scale missile. For subsonic work, it is essential that the Reynolds numbers be the same for the two cases. The Reynolds number is equal to dVL/u, where d is the density, V the velocity, L a dimension on the model and u is the viscosity. For testing models in a supersonic flow, the important constant is the Mach number, which is the ratio of the velocity of the missile to the velocity of sound. The Reynolds number is, however, also important. With the pressurized range it will be possible to vary the density of the gas inside the tube and thus to study the aerodynamic characteristics of missiles at the same Mach number but different Reynolds numbers. This will lead to a better correlation between model and full-scale data.

An Experimental Electronic Background TV Projection System

By WAYNE R. JOHNSON

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SUMMARY: The system is an electronic version of the process screen now used in motion pictures and television. Two television cameras may be mixed without superimposition. A contrasting white background screen in back of the foreground subject, which is always brighter than the subject, provides contrasting information. This information keys the two cameras on or off through an electronic switch. Details of the signal selection, modification of the keying signals and the use of delay lines are discussed.

Before proceeding we shall review a few basic principles of television in order more fully to understand the electronic process. Television is basically a scanning system; that is, the picture is divided into lines, and the transmitted signal is formed from a dot portion of a line which dot portion moves progressively from one end of the line to the other, retraces quickly back, and starts on another line. It takes 525 lines to make up one complete television frame and there are 30 frames in one second. Figure 1, trace A, shows an example of the electric signal corresponding to one horizontal line. The polarity of the signal as shown is white in the upward direction and black in the downward direction. The signal at each end of the line is the pedestal or blanking pulse which is black and which occurs during the retrace time of the scanning beam. It blanks out the retrace lines so that they will not show.

In order to superpose the television signals from a foreground subject and a background without securing a double exposure effect, a switching system is used to switch the output from the foreground to the background and back, as the scanning spot crosses the desired boundaries. This switch has to operate at a very fast rate—in the order of 1/10 μsec (microsecond) or quicker. To select the desired boundaries a switching signal is used, and to derive the switching signal a contrasting signal is needed from the studio camera which is taking the foreground subject. The contrasting signal can be white or black; we prefer a white backdrop with the foreground subject

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performing in front of it. No part of the subject can contain any portion appearing as white as the backdrop, otherwise wrong switching will occur in that region.

The light intensity radiated from the white backdrop is 150 foot-Lamberts. This is about the right amount for the type 5820 camera tubes. The stop opening is adjusted for the saturation point, that is,

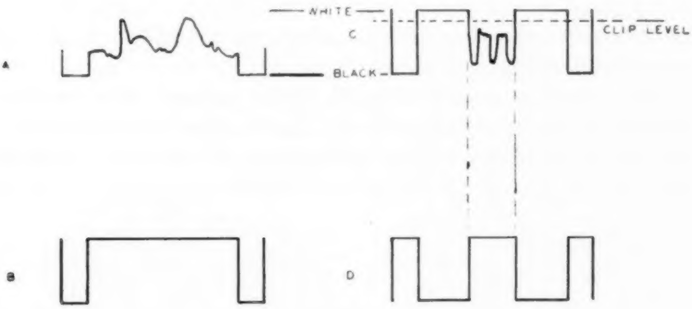

Figure 1.

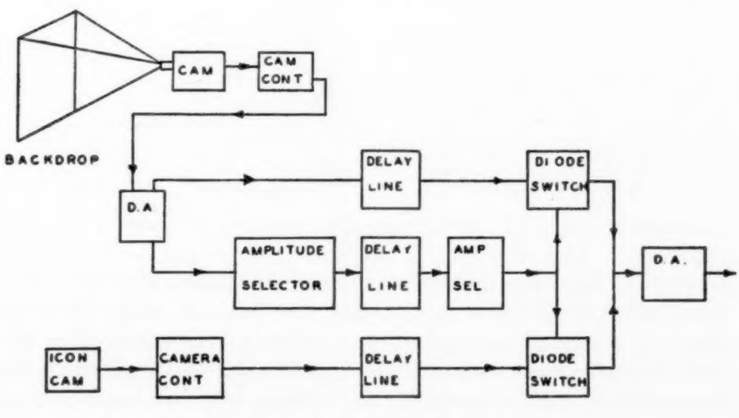

Fig. 2. Block diagram of the system.

at about $f/16$. Trace B in Fig. 1 shows the camera video signal with only the white backdrop present. Trace C shows the camera video signal with the white backdrop and with a foreground object between the backdrop and the camera.

As seen in the third trace, the white backdrop provides the contrasting information. To satisfy the need for a means of electroni-

cally isolating the white backdrop signal from the foreground object, an amplitude selection method is used, that is, a portion of the video signal is selected by the grid cutoff characteristics of electron tubes. The upper trace, C, shows the video signal at the grid of a tube; the dotted line marked "clip level" shows the grid cutoff point. The portion of the signal between this and the clear white level yields the resultant plate current, in the lower trace, D, which is in a form that could be used directly as a switching signal to switch between the foreground camera and the background information that it is desired to mix with the foreground subject.

Figure 2 shows a block diagram of the system. The foreground camera is in the upper left portion of the diagram. The white backdrop is in front of this camera and between the two is the foreground

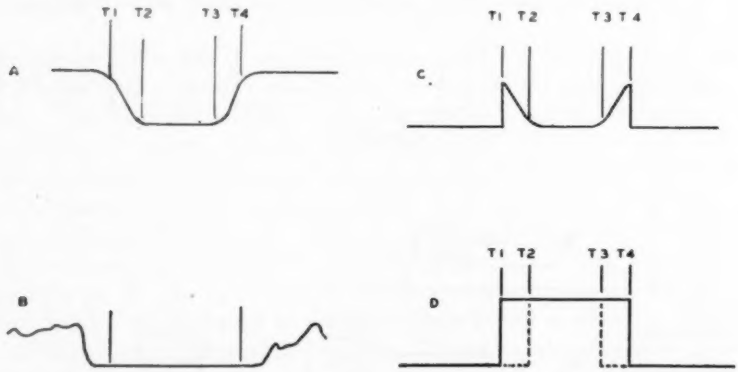

Figure 3.

subject. The video information from this camera then goes to a distribution amplifier which bridges the line and sends the video signal to the amplitude selection amplifier. This video signal also goes through a separate branch to form the pictorial signal when the foreground subject is switched in. Delay lines are used in both branches so that the times of transition in the foreground and switching signals match exactly at the final switching point. The output of the amplitude selection amplifier goes through a pulse narrowing system which will be referred to later. The switching signal from the latter system then operates a diode switch which has connected to one side of it the foreground video signal from the delay line. The background video signal from a camera or from a motion picture or slide projector is connected through an identical delay line to the other side

of the diode switch. The switching diodes are connected in opposite polarity so that, when one is on, the other is off. The common output of the diode switch is bridged by a distribution amplifier which changes the output impedance to 72 ohms and sends the composite mixture of foreground and background picture to the studio switching system.

Figure 3 shows in trace A an expanded view of a horizontal line from the foreground camera. The camera output at time T-1 is at white level and it is going to black level which is the foreground subject. Prior to time T-1 this camera was looking at the white backdrop and its output did not appear in the composite mixture, but was replaced by the background information. Television cameras do not have infinite detail so the transition from white to black requires a finite time. The speed of transition varies from 0.06 μsec for 600-line definition to 0.12 μsec for 300-line definition. It is this limitation

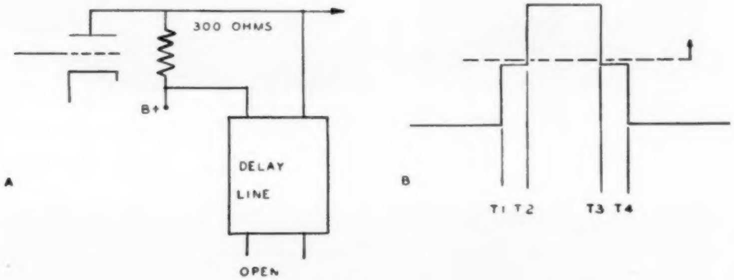

Figure 4.

that makes necessary a pulse narrowing device. Suppose the amplitude selector selects the signal at time T-1 and develops a switching signal at the same time—if the background information at this time is dark as shown in trace B it will, unfortunately, be turned off too early. Trace C shows the resultant video signal when this occurs. As the figure shows, a short white pip from the backdrop around the foreground subject will be obtained. The net result of successive horizontal lines is to produce a white ring around the foreground subject which is called halo. The same thing happens in reverse order when the switch turns the foreground subject off and the background subject on, that is, during the time from T-3 to T-4.

In order to correct for this limitation it is necessary to delay the switching signal from T-1 to T-2 and in reverse order advance the switching signal from T-4 to T-3, as shown in trace D of Fig. 3. Of course, there are no advance lines being manufactured at this time

Fig. 5A. The background scene.

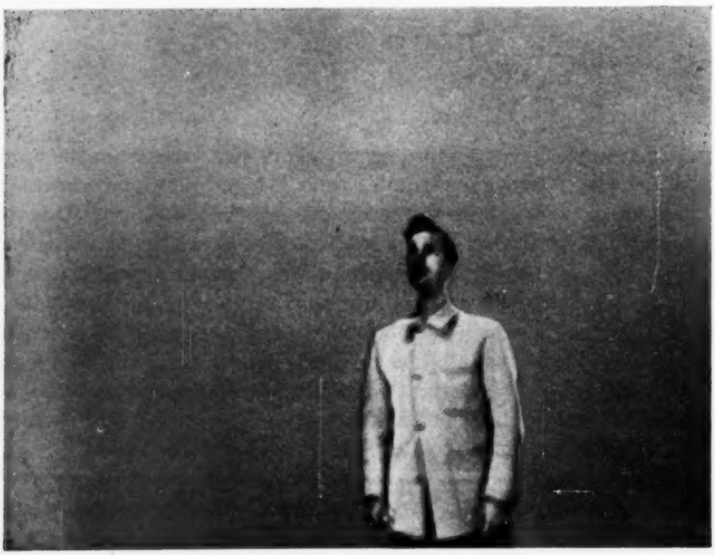

Fig. 5B. The foreground actor, with white backdrop.

and a different scheme is used involving the narrowing of the switching signal by means of a delay line. Figure 4 shows in the upper portion a delay line connected to the output of the amplitude selection amplifier. A 300-ohm line is used with the far end left open. The trace at the bottom of Fig. 4 shows the switching wave form as it is modified by the delay line. At time T-1 the voltage is one-half of normal because the driving impedance is in parallel with the characteristic impedance of the delay line. When the switching voltage returns $\frac{1}{10}$ μsec later from being reflected at the open end of the delay line it adds to the original signal at time T-2. At T-3 the switching voltage from the amplitude selector goes to zero, but the reflected signal from the open end of the delay line continues for an additional $\frac{1}{10}$ μsec. The modified switching signal is clipped by another amplitude selector which selects the narrowed portion of the pulse giving a switching signal that is $\frac{1}{10}$ μsec narrower. In the process of narrowing the switching pulse, an additional delay of 0.05 μsec has been incurred. This delay is compensated for by the video delay lines before the video signal arrives at the switcher. The timing has to be held to 0.01-μsec accuracy in order to prevent any trace of halo. So much for the electrical features of the electronic background projection equipment.

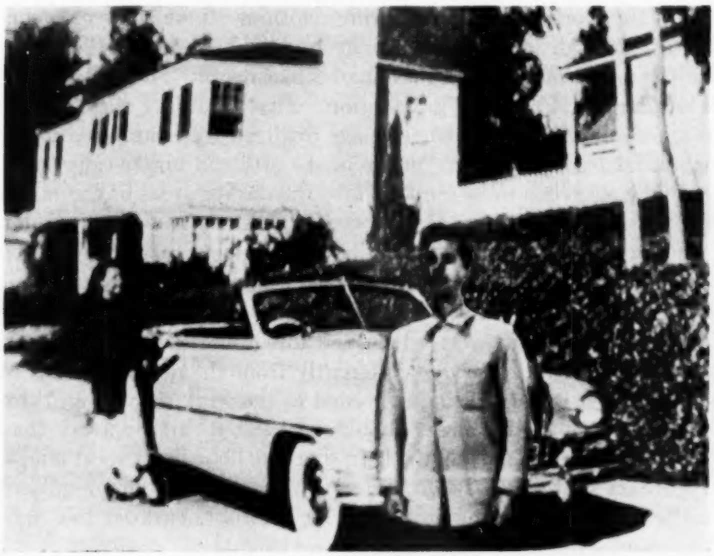

Fig. 5C. The composite picture.

Some of the characteristics of the composite mixture are of interest. For instance, the relation of the foreground picture to the background picture during the process of dolly shots and panning presents some problems and also offers some possibilities for unusual effects. The dolly shots are very realistic when the background picture is of an outdoor scene. The background picture remains stationary if it is a still, while the foreground picture is changing, that is, if the camera starts to dolly at a distance the actor first appears small, and then as the camera moves in the actor fills up more and more of the screen. At the same time, however, the background does not change. This gives the illusion that the background is at a considerable distance. If, on the other hand, the foreground camera is panning, some strange things appear to happen. The background remains stationary while the actor moves left or right as the foreground camera is panned. This gives the appearance that the actor has been moved by an invisible hand; there is no body action to indicate movement. If this effect is not desired the camera should be locked in azimuth and elevation. In normal shots this is not an insurmountable difficulty, and ways and means are being developed to eliminate it.

The nature of the system depends upon amplitude selection and this, therefore, places a limitation on the type of clothing that can be worn by the foreground performers and the type of lighting to be used in the working area. No white clothing should be worn since none of the high lights in the foreground subject should be greater than the reflection from the illuminated backdrop. The desired type of clothing would be in the gray region. Black clothing does not give too satisfactory a picture when image orthicon tubes are used in the camera. Large white areas on the image orthicon target cause some secondary electrons to be emitted into the darker areas of the target and causes the black areas to become lighter than they should. While normal type of makeup can be used in most cases, it has been found in some instances that a heavier type of makeup helps to subdue spectral reflections. Makeup on the hands has to be used for the same reason. The area in which the foreground subject performs needs to be lighted somewhat differently from the normal shots. A constant intensity of lighting is needed in the working area and this means that the light sources should be located farther away than usual. We have been using the long slim-line floor fluorescent lamps.

Figure 5A shows the background scene, and Fig. 5B the foreground actor with the white backdrop. In Fig. 5C is illustrated the composite picture obtained from the processed signal.

Effects of Incorrect Color Temperature On Motion Picture Production

By FRANK F. CRANDELL, KARL FREUND AND LARS MOEN

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SUMMARY: Past efforts to systematize control of film production (and especially color) have been partially defeated by inability to detect variations of color temperature of daylight and artificial light sources. Effects of such variations on tone or color of makeup, costumes and sets are cited. Steps necessary to complete control, and the part which color temperature of illuminants plays in each are indicated. A new instrument is described which makes the practical determination of color temperature a simple step. A more accurate method is proposed for the description of illuminants, color film and filters.

The time has passed when it is necessary to explain to a body of engineers what we mean by the "color temperature" of an illuminant. The concept of a black-body radiator and its Kelvin temperature is generally understood by illuminating engineers, studio technicians and workers in the field of color photography.

If the illuminants in general use were true black-body radiators, and if their color temperature were a factor of high constancy, there would be no problem in the application of such light sources to color photography and cinematography. Unfortunately, we are becoming increasingly aware that practical light sources represent only approximations, and often poor ones, of black-body radiators. It has, of course, long been realized that practical light sources vary constantly in their spectral distribution of energy, with serious results upon the exposure balance of color materials. In the earliest literature of color photography, there are frequent references to the instability of filter factors caused by the fluctuating color balance of light sources, and especially daylight. On the whole, in reading these early statements, one is struck by the fact that the subject was less complicated and easier to understand before the concept of equivalent color temperature was introduced.

In the following paper, we shall sometimes use the term "color temperature" for lack of a generally accepted term which would be more descriptive. We shall also, however, set forth the first results of a series of studies in the measurement of the color balance of practical illuminants, and make certain proposals concerning a more simple

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and informative method of designating this property of a light source.

Until fairly recently, color temperature might be said to have been the "hidden factor" in color film production and color photography. We knew about it, but because there was no available means of taking it into account, there was a natural tendency to ignore it. The color balance of a scene sometimes turned out correctly, and often did not, and when it did not the blame was usually placed on the manufacturer or the laboratory. The manufacturer, harassed by the difficulties of making color film with reasonably constant over-all speed, went on the simplifying assumption that the color temperature problem could be solved by the user of color materials. The processing laboratory, busy with the complexities of maintaining unstable baths at constant energy, likewise assumed that the color temperature of the taking illuminant could be ignored.

This simplification was undoubtedly justified as a practical measure during the period in question. Today, however, it is neither justified nor necessary. Now, that incident light measurement has been generally accepted as a means of exposure determination, the ASA Exposure Index[1] takes on real meaning, and the recent announcement of Eastman Kodak that professional color film materials will be packaged with a slip bearing the individual exposure index of that particular batch will mean that exposure determination will take on an increased degree of precision.

Improvements in laboratory procedure and the use of color densitometry now make it possible to hold the color balance of monopack or integral tripack materials to tolerances comparable with those in handling separation negatives on black-and-white film. Therefore, it would be fair to assume that results should now be perfect, but, as every practical worker knows, they are not. There must be another serious factor at work, affecting color balance—and this factor, of course, is the color balance, or temperature, of the taking light.

We believe, therefore, that the time has come to bring color temperature out into the open, to recognize it, and to try to solve the problems which it creates, just as these other problems have been solved. In addition to intensity of illumination, brightness range and contrast, we must now measure the color of the illuminant.

Even in black-and-white work, this hidden factor of color temperature has had an important effect on tone reproduction of different hues. Every cameraman has had the experience of being unable to duplicate the results of an earlier test, even when film bearing the same emulsion number was used. All the conditions seemed the same, but the fact

that he may have been given old lamps for the test and new lamps on the set, or may have used "nets" instead of dimmers, may have been enough to shift the spectral distribution of the illuminant, and with it the spectral sensitivity of the film.

Even now, this question would be purely academic if no instruments were available for the measurement of color temperature. Such instruments are available, however, and their use will undoubtedly become an integral part of professional procedure. The professional worker knows that if certain factors are to be measured and controlled, then all factors should be similarly measured and controlled, or the final result may be worse rather than better.

Nor should it be felt that this complete application of measurement restricts the freedom of the artist. The cameraman, as artist, will still be free to deviate from the norm in any direction which he desires, with the added benefit of the assurance that the results will be what he wishes.

Before dealing further with the applications of color temperature measurement in motion picture production, we shall describe briefly the problems of designing an instrument for this measurement, and give one solution of the problem.

Awareness of the effects of incorrect color temperature on color balance is not new. When Wall wrote his *Practical Color Photography*[2] in 1922, he said: "Theoretically, one ought to determine the filter ratios before each exposure, as the color composition of daylight varies considerably, being much richer in red and green in sunlight than in shadow or in cloudy weather. But if the filter ratios have been determined, one may ignore this factor, at any rate at first." Considerably earlier references may be found in von Hubl, Koenig, and others.

Despite this awareness, surprisingly few efforts have been made in the past to provide the photographer with a means of measurement and control. Two visual instruments have been placed on the market. The first was based on the visual match of a yellow filter and an additive mixture from red and green filters. The second relies on a "dichroic" filter which appears pink under one type of illuminant and bluish under another. Such meters have undoubtedly been of considerable assistance when used correctly, but are unavoidably affected by the adaption and condition of the observer's vision.

For this reason, it was felt worth while to develop an instrument which would not involve judgment, or any subjective factors, despite the many design problems involved.

The term "color temperature" has three meanings at the present

time: a particular spectral distribution of energy, a visual appearance which matches a particular spectral distribution, or (in photographic literature only) a certain ratio of photicities in three broad zones of the spectrum.

The instrument in question has been designed with a full awareness of this triple nature of color temperature, and to a high degree, the instrument is suitable for the measurement of all three.

If radiation is close to the true spectral distribution of black-body radiation, then the ratio of the measurement at any two points in the spectrum will be characteristic of one color temperature only, and if the instrument is properly calibrated it will be possible to measure the color temperature of true black-body radiation accurately over the desired range. This can be done with an accuracy well within the range of least perceptible differences.

Any two points in the spectrum might serve, but for maximum precision it is desirable to have the distance between the two points great enough so that filters with no overlap may be selected.

In the case of visual color temperatures, the instrument becomes in effect a photoelectric colorimeter, and the visual sensitivity curves used in standard colorimetry must be taken into account. Any two of these might be used, but since it has already been decided that there shall be no overlap, the best choice would seem to be the blue and the major portion of the red. The fact that the secondary maximum of the red sensitivity curve (in the blue) is not present in the red filter becomes without significance in this case, since the secondary maximum would alter the blue–red ratio by a constant factor, and this cancels out in the calibration of the instrument.

Thus, in the case of light sources with continuous spectra, the instrument will give the color temperature of the black-body radiation for which the illuminant in question is a visual match.

In the third case, that of photographic color balance, the problem is simple and straightforward. We are interested in measuring the amount of red and blue, and sometimes green, in three relatively broad zones with well defined maxima. While different color processes vary somewhat in the boundaries of these zones and in the precise location of the maxima, the similarities are far greater than the differences, and the agreement is close enough to make it entirely feasible to select reference points for measurement which will be valid for all present processes with precision well within the permissible tolerances.

The same red and blue filters which were selected to meet the second condition also serve for the third purpose, that of measuring photo-

graphic color balance. When departure from the correct amount of green is suspected, this can be checked by the use of the third filter, green, with which the new professional model of the instrument is equipped. If the amount of green is not that for which the red–blue ratio would call, in accordance with black-body standards, the meter will at once indicate it, and corrective measures may be applied.

The curves shown in Fig. 1 represent the effective sensitivities resulting from the combined effect of filters and barrier type cell.

How this is accomplished will immediately be clear from the following description. The body of the instrument consists of a circular housing, about 4 in. in diameter, with a pistol-type grip on the bottom for convenience in aiming the instrument at a light source. The body has a gray crackle finish. On the front of the circular housing is the opening through which light enters the instrument, surrounded by a knurled ring which is coupled to the diaphragm over the light cell. This diaphragm consists of two overlapping sectors with serrated edges. Behind this diaphragm is a red filter, through which the light passes before reaching the barrier-type cell.

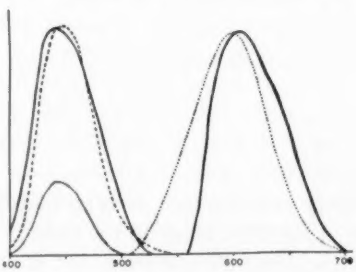

Fig. 1. Comparison of the standard blue and red visual sensitivity curves (dotted curve and dashed curve) with the sensitivity of barrier cell plus blue and red filters in a commercial color temperature meter.

On the back side of the circular housing, set at an angle for easy visibility, is the needle and scale of the milliammeter. On this scale is a red mark. The user points the instrument at a light source and adjusts the diaphragm ring until the needle coincides with the red mark. All that remains is to pull the trigger set in the front of the pistol grip. This replaces the red filter with a blue filter, and the scale reading then gives directly the color temperature of the light source, or the deviation from a standard temperature and the correction filter to use to bring the illuminant to that standard, depending on the scale in which the instrument has been calibrated.

One accessory to the instrument should be mentioned. This is a frosted glass hemisphere, completely neutral in color, which may be fitted over the front of the meter. This is for use when the prevail-

ing illumination is not all of one color, and it is desired to obtain a practical average value.

When measurement of the green is desired as well, for illuminants which are not a good approximation of a black-body radiator, it is a simple matter to add a green filter and a second trigger position. This is now being done on a new professional model which will be ready shortly. The significance of this green measurement, and the relation of readings to the use of corrective filters, will become clearer in a later section of this paper, in the discussion of a proposal for an improved method of specifying the color balance of an illuminant. We will first consider some of the possible applications of color temperature measurement to actual studio procedure.

When we speak of color temperature today in the motion picture industry, as already mentioned, we may mean any one of three quite different things: (1) We may mean true black-body radiation, or a close approximation thereof. (2) We may mean a light source which is a visual match for such black-body radiation, even though its spectral distribution is vastly different (and such a light source corresponds to the meaning of the adopted American nomenclature). (3) In purely photographic and cinematographic terminology, by color temperature we may mean merely the proportions of red, green and blue radiation in a light source, which balance the sensitivities of a particular type of color film—a light which may be neither black-body radiation nor a visual match for such radiation.

This third usage of the term is not met with in the scientific literature, properly speaking, but is the common usage in motion picture practice, and as such is worthy of a little more consideration than has as yet been given to this subject. In motion pictures, and in color photography generally, we are not concerned with the conformity of a light source to a particular black-body distribution of radiation. What we are interested in is a continuous spectrum in the three broad bands or zones of the spectrum which will be recorded on the film, and it is desirable that the general curve of spectral energy distribution be reasonably smooth, so that it will not show any unpleasant surprises in connection with colors having narrow absorption or reflectance bands. With this qualification it is only necessary that the energy which falls in the band of the blue filter or sensitization, the green filter or sensitization, and the red filter or sensitization have a proper ratio to the total of the three or to each other, since this will ensure color balance. Actually, it would be more accurate and correct, and more easily intelligible, to the average nonspecialist in colorimetry if we were to use the term "color balance" of the illumi-

nant rather than color temperature, since it is color balance that is actually meant.

In setting up a color process, whether it be one which uses three separate negatives, like Technicolor, or an integral tripack coated on a single base, such as Kodachrome and Ansco Color, the maker balances the film for a particular color ratio in the taking light source. So far as we are aware, very little information has been released by Eastman Kodak and Ansco on the procedures involved in this and the standards used, and it might eventually become an important contribution to a better standardization and simplification of nomenclature in this field if the manufacturers were disposed to co-operate in setting up specified procedures. It must not be forgotten that the illuminant under which color motion pictures are taken is not an end in itself but solely a means to an end, that end being a positive color film which the ultimate beholder will find agreeable and acceptably realistic.

Color temperature, in motion picture production, is not an academic question. Given a particular color process and a particular batch of film, what is desired is to make a balanced set of negatives on that film, using whatever light may be necessary for that purpose regardless of what this light may be called or how it may be classified. The basic conditions to be satisfied in this direction were laid down many years ago, when the practice of color photography was in an almost purely empirical state, in terms of what is known as "the first gray condition" and "the second gray condition." The first gray condition specified that a neutral gray, photographed through the three taking filters, shall produce equal densities in all three negatives, and the second gray condition specifies that equal densities in the three negatives shall produce a neutral gray, or a good approximation thereof, in the finished positive. Today, we should probably modify that a little bit, recognizing that in such processes as color development and some other means of forming colored images, equal silver densities do not necessarily yield equal dye densities. Therefore, the "first and second gray conditions" could probably be more accurately reworded to say that "a neutral gray object, photographed through the three filters, shall produce *correctly balanced* densities in the three negatives, and that correctly balanced densities in the three negatives shall be those densities which produce dye densities in the positive giving the best neutral gray of which the process is capable."

The simple statement of the problem in this way holds the whole basic question of photographic color temperature, and helps to point up the fact that what we are interested in is not color temperature *per se*, but a certain specific and definite ratio of silver densities in the

negative image and a certain ratio of dye densities in the finished positive.

Nothing will emphasize the absurdity of the present color temperature nomenclature in relation to photography and cinematography more than the necessity of explaining the matter to someone previously quite ignorant of it. At the present time, one is first obliged to explain the concept of a black-body radiator, an abstraction not too easily grasped by the nontechnical mind, then the complex mathematics of determining the distribution of energy in the radiation from a black body at different temperatures, the character of light emitted at the different temperatures, and so on. After this somewhat lengthy beginning, it is then necessary to confuse completely the person to whom the explanation is being given by explaining that what we have just told him is color temperature, but that what we are talking about is not that but something quite different. Then, it is necessary to go into the explanation of equivalent color temperature and light sources which are a visual match for a particular color temperature, after which we must again explain that that is not what we mean either, but that color temperature in relation to photography actually means the balance of red, green and blue in certain important sections of the spectrum, such balance to be similar to the balance of those same zones in a black-body radiator.

"Color balance of the illuminant" is probably too clear and simple a term to find favor as a new nomenclature, but there assuredly is a drastic need for a simple term which will make it clear that we are concerned with the balance of three specific zones and not with black-body radiation or a visual match for it. If, as we believe to be wise, a new term is sought, it would seem desirable at the same time to adopt a more rational system of numerical evaluation than that employed in the color temperature system. Judd[3] pointed out 14 years ago that the use of the reciprocals of Kelvin temperatures would give rise to a scale in which the least perceptible difference in color temperature to the observer would remain more or less constant, whereas on the Kelvin scale it differs sharply from zone to zone. At 3200 K (degrees Kelvin) for example a difference of slightly less than 50 K is a perceptible difference, whereas at 6500 K, the least perceptible difference is in excess of 200 K. On the other hand, if these are expressed in terms of Micro-Reciprocal Degrees or Mireds (obtained by dividing the Kelvin temperatures into 1,000,000) we find that the least perceptible difference represents about the same number of Mireds over the entire portion of the scale in which we are interested. A temperature of 3200 K becomes 312 Mireds, and 6500

K becomes 154 Mireds, and in both cases the least perceptible difference would be approximately 5 Mireds. This least perceptible difference is not a constant throughout the whole of the Kelvin scale, but as Judd[3] has pointed out, it is substantially constant from 1,800 to 11,000 K, which fully covers the range in which we are interested.

There would seem, therefore, to be every practical advantage in specifying light sources in terms of Mireds rather than degrees Kelvin, when we are discussing their visual appearance. However, the Mired, as a unit, still fails to convey directly the information in which we are interested for photographic purposes, and we shall propose a further standard later in this paper, though we shall relate it to the Mired.

One field which calls for definite investigation is the establishment of tolerances which will specify the permissible variation in color of the taking light. We know about what this should be when we are dealing with direct visual perception, but we do not know what difference in the color of the illuminant will produce a just perceptible difference in a color photograph taken by that illuminant.

Presumably, since the color photograph is of lower saturation, the tolerance is somewhat greater. Presumably, also, the better the subtractive primaries the more critical the balance, the poorer the primaries, the greater the tolerance. We know, for example, that when a letterpress printer has difficulty in controlling the balance of a three-color job, he deliberately "grays" the process inks by contaminating them with each other, so that the balance will be less critical.

We may assume that in an ideal process of color photography, the photographic tolerances would be the same as the visual tolerances, or about 5 Mireds. As to actual processes, we have little data. Dr. Spencer, in an investigation made in England before the war, found that a density variation in a Carbro separation positive of about 5% represented the permissible limit. This is roughly equivalent to 10 Mireds illuminant color difference, or two visual steps. Eastman Kodak recommends a tolerance of about the same amount for Kodachrome.

So, while we should not infer too much from these unrelated observations, as good a guess as any at the present time would be that on current processes the photographic tolerance is about twice the visual tolerance.

However, it is not suggested that the use of this doubled tolerance in the exposure of color film would be good practice, for two reasons: first, because as processes improve, the photographic tolerance will approach the smaller visual tolerance, and second, because if we utilize

the full tolerance of imbalance at the time of shooting, no tolerance is left for the manufacture or processing of the film.

A practical and sound tolerance, then, which we believe should be recommended at this time, is ±5 Mireds. At tungsten temperatures, this represents about ±50 degrees K, and at daylight temperatures, ±200 degrees.

Permissible variation in directions away from the black-body locus remains to be investigated.

Before going farther, we shall consider the steps involved in complete color control in the studio, after which we shall take up a proposed means of systematizing such control. The major steps which affect the validity of color reproduction in a motion picture are the following:

1. Selection of correct subject matter.
2. Use of illuminants of correct color balance while shooting.
3. Correct color balance of film sensitivities and filter transmissions.
4. Use of a camera objective which is reasonably nonselective.
5. Balanced negative processing.
6. Balanced printing of the positive.
7. Balanced positive processing.
8. Projection with light of uniform color, both in distribution and duration (and preferably as white as possible), and with a minimum of stray light reaching the screen.
9. A screen which is reasonably nonselective.
10. An observer with normal vision.

With slight exceptions, these steps apply with equal force to all processes in use at the present time, and we shall briefly consider the part which the color balance of illuminants plays in several of these steps.

1. Selection of Subject Matter. This involves the choice of fabrics for costumes, pigments for set decoration, cosmetics for makeup, and many other items. Some of this choice is done by visual color matching, some by practical tests shot in advance. In the case of visual matching, it seems to us particularly unfortunate that there is a general tendency in the studios to do this under fluorescent lighting. As Nickerson,[4] Evans, and others have recently pointed out, the presence of strong blue and orange monochromatic bands in these illuminaires leads to considerable distortion of colors with fairly abrupt absorptions and reflectances. The use of properly filtered tungsten sources would lead to more consistent and reliable color matching and selection, particularly in the makeup department. Such sources should be checked frequently for proper color with a

suitable meter. With standardized color matching sources of this type, makeup colors could be standardized, ending the present chaos. Different studios, using the same Technicolor process, employ sharply differing basic makeup colors. Which are correct? Which are better? It would seem that this might well be a matter for the attention of the Research Council of the Academy of Motion Picture Arts and Sciences, rather than the individual manufacturer of cosmetics. As regards camera tests of makeups, fabrics and the like, it goes without saying that the color of the illuminant should be rigorously controlled, so that it may be duplicated during production.

2. Taking Illuminant. The causes of variation in the color of the prevailing illumination on the set or on location are so numerous that an entire paper could easily be devoted to them. In the studio, the type and age of lamps, the line voltage, silks which grow yellow, filters which fade, arcs which smoke—these and a score of other factors—make the color of set illumination problematical. In the open air, there are comparable variations due to meteorological and geographical conditions. We know that reasonable errors in balance can be corrected later, provided the error is fairly constant over the entire frame. Nothing can be done, however, if it is a single face, or a single portion of the set. Control by means of suitable instruments will reduce the need for laboratory correction to a minimum, and should virtually eliminate scenes which cannot be corrected.

3. Film and Filter Balance. We know that there is some unavoidable variation in manufacture, in the age of the film, and so on. However, if we hold our tolerances closely on the color of the taking illuminant, the requirements of a particular emulsion number can be determined accurately and closely met. Naturally, we must be sure there is no serious image regression through too long storage after exposure and before development, since this affects balance very adversely.

4. Nonselective Objective. This is a minor item, but yellowed balsam in an old lens can affect blue transmission perceptibly, and low-reflectance coatings which are all of the purple type can drop red and blue transmission as much as 6%. All blue or all yellow coatings give an even worse result. The remedy, of course, is to discard old and yellowed objectives, and to have low-reflectance coatings applied with a suitable mixture of purple and brown surfaces.

5. Negative Processing. This has been so adequately dealt with in other papers before the Society that there would be no point in repetition here; however, better standardization of illuminant, film and filter relationships will obviously make it easier to obtain uniform laboratory results.

6. Balanced Printing. This again calls for accurate control of the color of the illuminant (especially in the case of multi-layer materials). Tolerances should be held as closely as on the set, which means photoelectric measurement.

7. Positive Processing. This has also been covered. If previous steps have been held within desirable tolerances, this step should offer less difficulty than at present.

8. Projection Light. The light reaching the screen should be reasonably white, uniform in color over the screen, and uniform in color when making a change-over.

9. Projection Screen. Should be reasonably nonselective. Photoelectric control is useful to check the combined performance of light source and screen.

10. Normal Observer. If the observer is color blind, there is nothing we can do about it. We can, however, be reasonably sure that the responsible personnel working with color have normal color vision, since the unsuspected presence of an individual with some form of color blindness can cause much waste and confusion.

So much for the steps in production at which control may be exercised. We have purposely curtailed this section somewhat, because we feel that more importance attaches to a proposal which we shall make for a new system of measuring and specifying the color balance of illuminants instead of the Kelvin color temperature scale. After all, an adequate system of measurement and description is the essential first step toward better control, so all of this is extremely pertinent to the general subject of the paper.

Dissatisfaction with the term "color temperature" and all that it stands for is not precisely new, but it has recently become insistent. Nickerson[4] said, in a paper at the last meeting of the Society:

"The specification of the color of sources in terms of color temperature without an understanding of the limited meaning of the term has caused much confusion in color thinking as it concerns the illuminant... For any real understanding of color processes, whether visual or photographic, it is necessary to take into consideration the more exacting specification of spectral distribution. Thus, while illuminants in this report are often referred to in terms of the color–temperature scale, it should be remembered that it is not their color but only their spectral characteristics that will tell whether they are suitable for use with a given film, or to produce a specified result."

Evans[5] says, in his invaluable book: "The usage of the term is exceedingly confusing and it appears inevitable that sooner or later a new terminology will appear."

Moon[6] says, in the report of the Optical Society of America Committee on Colorimetry: "...the concept of color temperature...still serves as a rough engineering specification. However, one may expect it to decline gradually, to be replaced by the much more satisfactory spectrophotometric curve and by the colorimetric methods of Chapter XIII."

To this, Jones and Condit[7] add the following comment in a recent paper before the Optical Society of America: "Our feelings are somewhat stronger than those of Moon concerning the discontinuance of the usage of the term 'color temperature,' particularly in the field of photography. We should like to recast the last sentence of the above quotation to read as follows: 'However, we hope its use in the field of photography will decline rapidly or cease abruptly and be replaced by...etc.'"

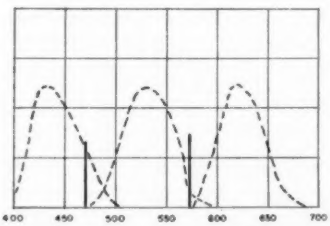

Fig. 2. Two monochromatic lines, at 470 and 573.1, visually match Illuminant C but would photograph as pronouncedly blue, as shown by dotted trichromatic filter curves.

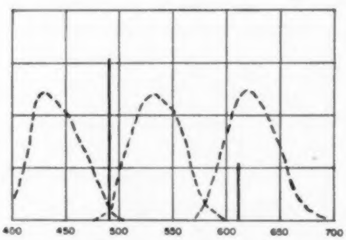

Fig. 3. Two monochromatic lines, at 490.4 and 610, visually match Illuminant C but would photograph as red.

Our own work in the field of illuminant color measurement has made us extremely conscious of the shortcomings of Kelvin temperature, which has led us to seek something more descriptive.

The inadequacy of visual-match color-temperature as a standard for color photography can be best shown by taking a few extreme cases. In Fig. 2 is shown the spectral distribution of a light source which emits two monochromatic lines, as shown. Colorimetrically, this is a visual match for Illuminant C, the artificial daylight of colorimetry. Photographically, as shown by the three filter transmissions indicated in dotted lines, this illuminant would photograph as a bright blue. The source shown in Fig. 3 would photograph as bright red, yet visually it matches Illuminant C. Lastly, that shown in Fig. 4 also matches Illuminant C, and would scarcely record on normal color film at all.

These are extreme cases, but it would be a mistake to assume that they are irrelevant. The rising popularity of lamps with strong monochromatic lines, even though these be superimposed on a continuous spectrum, makes it necessary to stress as strongly as may be that their use as illuminants for color photography leads to many unpleasant surprises, and may be misleading in the selection of fabrics, makeup, pigments and the like.

The need for a direct adequate method of specifying the red, green and blue energy content of an illuminant makes it worth while to review a proposal put forward a few years ago in connection with the spectral sensitivity of photographic materials. Dr. D. R. White,[8] as a member of the Subcommittee on Sensitivity to Radiant Energy of the American Standards Assn., put forward a proposal which is extremely pertinent in this connection. Although his proposal was

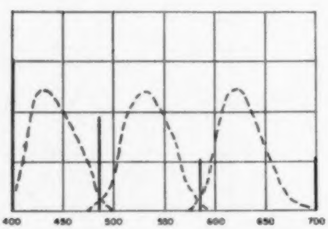

Fig. 4. Four monochromatic lines, at 400, 485, 585 and 700, visually match Illuminant C but would scarcely record at all on color film at ordinary exposure levels.

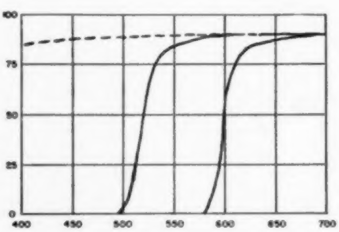

Fig. 5. Transmission curves of standard Wratten filters proposed for division of spectrum into appropriate zones: dotted line, No. 0 filter; center No. 12; right, No. 25.

limited to monochrome reproduction and to a single illuminant, we should like to point out a way in which it could be extended to cover color film and color processes, the color balance of light sources, and the calibration of correction and compensation filters.

Since Dr. White's proposal is available in the literature, there is no need here for more than a brief summary. Basically, what he proposed was a simple means of measuring the relative percentages of the total sensitivity of an emulsion to Illuminant C, in the red, in the green and in the blue, and a simple index number in which three values would completely characterize that sensitivity.

This simple and direct approach involved only the determination of filter factors. Thus, if the material required ten times the intensity of Illuminant C through a No. 25 red filter to produce a suitable standard density that was required with no filter (a filter factor of 10)

it was evident that the sensitivity in the red was one-tenth of the total sensitivity. Similar filter factor determinations in the green and blue would assign values for all three zones. However, since the notorious inefficiency of green and blue filters would make special correction factors necessary, Dr. White adopted the artifice used years before by Dr. Eder and used a red, a yellow and a colorless filter, of substantially equal efficiency. The unfiltered value minus yellow filtered value then gave a total blue reading, and yellow minus red gave the full green sensitivity.

The resulting percentages were expressed in a system of indices which it would be pointless to reproduce here, since the steps were too great for the differences which are significant in color photography. Let us see what happens, however, when we extend the system to light sources, color film and corrective filters.

Dr. White's proposal was to rate the sensitivity of black-and-white materials in relation to Illuminant C, which was a logical simplification. Color processes, however, introduce a completely new relationship between illuminant and sensitized material—a reciprocal relationship between the spectral distribution of energy in the light source and the spectral distribution of sensitivity in the film, so that an illuminant of the correct color will record balanced densities in the film.

Since the color of the light source becomes the most important variable, in this case, and since it is to the illuminant that corrective measures will be applied, it has seemed to us logical to take the illuminant as the point of departure for the entire system.

What we have done is, first, to evolve a numerical index which accurately describes the spectral distribution of energy in the light source, in terms of those attributes which have a bearing on color photography. The color film or process is then rated in terms of the index of the illuminant which will produce the most nearly neutral image of a neutral object. Corrective filters are rated in terms of the change which they introduce into the illuminant before it reaches the film. Thus, illuminant, filters and film are rated in identical units, all derived objectively from easily obtained data.

The first problem, then, is to find an index which will express the relative amounts of energy in three bands of the spectrum, suitably measured. For the isolation of these bands, the filters proposed by Dr. White seemed eminently suitable, with one modification. He proposed to use the Wratten Filter No. 25 for the red, the Wratton No. 12 for the yellow, and no filter for the white light exposure, a suitable correction factor being applied to the white light data to simulate the filter losses by surface reflection in the yellow and red light expo-

sures. To eliminate this additional step in computation, it has seemed to us more convenient to make the white light measurement through a Wratten No. 0 plain gelatin filter. All the data to be presented are based on this set of filters, Nos. 25, 12 and 0. It should be pointed out in passing that glass filters have been made with very similar transmissions, and if it is felt that complete stability of the primaries is more important than general availability, a closely matching set of glass filters could be produced. Curves of the three gelatin filters used are shown in Fig. 5; and in Fig. 6 are shown the effective red, green and blue transmissions which result after the subtraction of red from yellow and yellow from colorless. As will be seen, the fictitious filters which result from this artifice are considerably better than actual green and blue filters. The transmission maxima are all high,

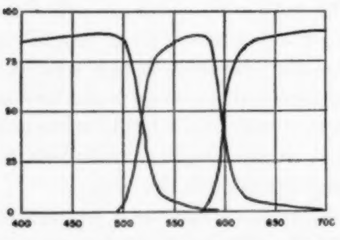

Fig. 6. Fictitious filter curves which result when transmission of No. 12 is subtracted from that of No. 0 (left); when No. 25 is subtracted from No. 12 (center); and real curve of No. 25.

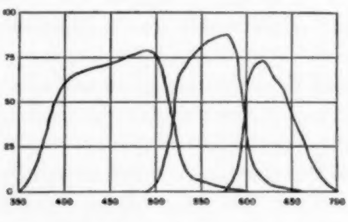

Fig. 7. Curves of Fig. 6 combined with spectral sensitivity of a typical barrier cell. This gives the proposed cutoffs at the long and short-wave limits.

and the cutoffs are steep. Furthermore, they show a good degree of similarity to the curves of leading color processes.

A special word needs to be said at this point about the boundaries of the red, green and blue zones. The boundary between blue and green lies at 518, and that between green and red at 598. This leaves the question of the long and short wave limits to be fixed. It is our belief that the blue zone should extend to 350, at which point it should approach zero, and that the red zone should reach a negligible value at 700. These limits are in good agreement with available data on color film sensitivities, which we are not at liberty to make public. Furthermore, the proposed set of filters, 25, 12 and 0 gives this sort of over-all response when used in conjunction with a suitable barrier-type cell, as shown in Fig. 7, where filter transmissions are applied to the sensitivity of a particular cell used for colorimetric purposes.

This means that photoelectric measurements may be taken which can be expected to show a high degree of similarity to the behavior of color film under the same conditions.

However, all of the computational results presented in this paper were obtained with an arbitrary set of primaries which cut off the blue at 400 and the red at 675. This was necessary because complete and accurate data were not yet available on the band from 350 to 400. However, such trials as have been made have shown that this extension of the boundaries will not affect the principal results in any material way, with the possible exception of one or two arc sources which are entirely incidental at this point.

To summarize, then, the data on which this paper is based are derived from an arbitrary set of primaries:

Blue. A Wratten Filter No. 0 minus a No. 12, with a cut-off at 400.

Green. A No. 12 minus a No. 25.

Red. A No. 25, with a cutoff at 675.

The first step was to compute the energy transmitted by these filters for a whole series of black-body radiators, from 2,000 to 12,000 K, or from 500 to 83 Mireds. Values were computed at 2,000, 3,000, 3,200, 3,250, 3,400, 4,000, 5,000, 5,900, 6,100, 7,000, 10,000 and 12,000 degrees.

For each illuminant, the energy was integrated for all three filters. For example, at 164 Mireds (6100 K) the totals were: blue, 1105; green, 720; and red, 586. Reducing these to percentages gave: blue, 45.8%; green, 29.9%; and red, 24.3%.

The first intention was to use these percentages as an index, but a few trials showed that three digits would have to be used for each color to distinguish illuminants with just perceptible color differences, so this was abandoned as impractical.

The system proposed by Dr. White—to multiply the percentages by 20, then take the logarithm—was tried also, but likewise failed to distinguish between small steps with a small number of digits in the index.

It then occurred to the writers that a ready-made system existed, with which a vast number of studio technicians and other engineers were already familiar: the decibel system. The decibel is, of course, drived by finding the log of a ratio, then multiplying it by 10 if referring to a power ratio, or, by 20 if referring to a voltage ratio. For the light energy ratios used as example in this article, a ratio multiplier of 20 was used. Each color was considered as the ratio of its energy to the total energy in the three zones, and this ratio was converted to decibels. In the example already given, the percentages

worked out as follows: 45.8%, 13.22 db; 29.9%, 9.51 db; and 24.3%, 7.71 db.

Since we are interested only in ratios, and not in absolute energy levels, and since the three always add up to 100% or unity, it was obvious that two of the values would be enough to describe the light source. The red value was, therefore, subtracted from all three decibel values, reducing red to zero and the others to proper relative levels. Numerous trials had shown that the second figure after the decimal point could be dropped without loss of the specified accuracy, so the adjusted values became: blue, 5.5; and green, 1.8; with "red 0.0" implied. This was expressed as an index in the form 5.5/1.8, which immediately tells us that in comparison with red, blue is "up" 5.5 db and green is "up" 1.8 db. In other cases, of course, either or both may be "down" as compared to red, in which case the db values are preceded by a minus sign. For want of a better name, we call this Spectral Distribution Index, or SDI.

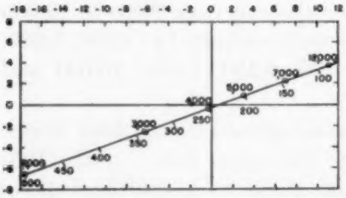

Fig. 8. Straight-line locus which results when decibel values of blue-red ratio (horizontal axis) and green-red ratio (vertical axis) are plotted against each other, 2,000 to 12,000 degrees Kelvin. Mired values (below the locus) are spaced linearly for the limits within which Wien's law is valid.

However, as an example of the results obtained with one set of primaries, the graph is shown in its entirety in Fig. 8 and with certain areas on a larger scale in Figs. 9 and 10.

As regards the Spectral Sensitivity Index, or SSI, to be applied to the film, it seems to us that the simplest procedure is to describe the film in terms of light to which it is balanced. Thus, a color film balanced to an illuminant with an SDI of −4.9/−2.0 would have the same figures as its SSI. Actually, of course, the sensitivities are reciprocal, but we are not interested in sensitivities per se, but only in their equilibrium with a certain spectral energy distribution.

Calibration of correction filters is greatly simplified by the use of the decibel concept. A filter is rated in terms of the decibel reduction which it effects in each zone, and this figure is arrived at by multiplying the filter density in the blue, the green and the red by 20. Since this density may be measured on a color densitometer, or computed from an accurate spectral curve, calibration becomes an extremely simple matter.

We would suggest, however, that the Spectral Absorption Index, or SAI of the filter, should retain all three values rather than be reduced to a form which eliminates the red. In this form, the gray content, or density common to all three colors, will be evident, and the index will show both the change in color of the light and the exposure increase, if any.

If, for example, a filter with an SAI of 1.0/0.5/0.5 is used with an illuminant of index 6.0/1.8, we should make the following simple computation:

6.0	1.8	0.0
1.0	0.5	0.5
5.0	1.3	−0.5

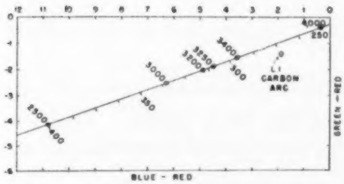

Fig. 9. Enlarged section of the db locus, taking in commonly used incandescent lamp Kelvin temperatures; as might be expected, the point representing the light from a low-intensity carbon arc is off the black-body locus.

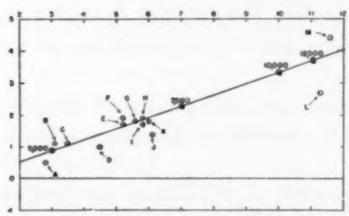

Fig. 10. Enlarged section of db locus, taking in sources of higher temperature: A, studio broadside; B, 170 M-R with Y-1 filter; C, average noon sunlight; D, Technicolor unit with Whitelite 6300 filter; E, daylight falling on horizontal plane, fairly clear; F, same on a clear day; G, sun outside earth's atmosphere; H, Graf A. C. high-intensity arc; I, complete overcast; J, Technicolor unit with Whitelite 7100 filter; K, Illuminant C; L, sunshine white flame arc; M, north sky light on a clear day.

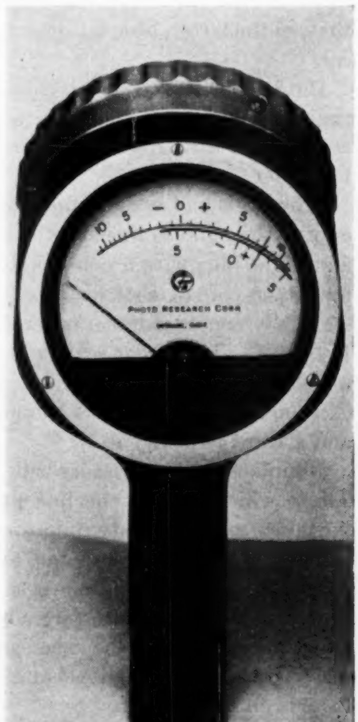

Fig. 11. Spectra Color Temperature Meter fitted with the proposed new decibel scales indicating the blue-red and green-red ratios.

Adding 0.5 to all three, to bring red back to its zero level, we have:

5.0	1.3	−0.5
0.5	0.5	0.5
5.5	1.8	0.0

This reckoning, which would usually be carried out mentally, tells us that the illuminant has been reduced to an SDI of 5.5/1.8, or, in other words, Illuminant C has been reduced to 6100 K. The total energy loss is 1.0 + 0.5 + 0.5, or 2 db, which must be made up by a suitable exposure increase, 6 db corresponding to one full stop.

For purposes of quick comparison, and to illustrate the concise manner in which information is conveyed, it may be mentioned that while 6100 K is 5.5/1.8, Illuminant C is 6.0/1.8, which tells us at once that, in the latter, blue is up another half a db and that green is identical.

Having derived the index values for the selected series of black-body radiators, the next step was to plot them on a graph. This was carried out, with green db values along one axis and blue values along the other.

When this had been completed, a very interesting and useful property of the index emerged: the locus connecting all of the points was a straight line, with a completely linear scale of Mired values. This meant, of course, that least perceptible color differences were a substantially constant linear amount from 500 to 91 Mireds, or 2,000 to 11,000 K. The linear scale and the perfect straightness of the locus make it both easy and safe to interpolate values, and probably to extrapolate as well. Two computations serve to establish the locus, and a third to verify it.

Nonblack-body radiators will, in general, fall at points off the line. Those which fall on the line may be considered, for photographic purposes, as black-body radiators.

There would be little point, at this time, in publishing the decibel values for all of the illuminants studied, since this work will be repeated in the near future with a corrected set of primaries. This may affect the gradient of the locus, and the reference level, but there is no reason to anticipate any change in the over-all relationships which have been established.

All of the foregoing can be applied by the manufacturer, who could mark the film and filters with appropriate values, but even without this there would be little difficulty in the application of the system by a single user. The foregoing procedures can easily be correlated with standard color densitometric procedures. The laboratory could

advise the cameraman as to the best illuminant for a particular emulsion, and if the cameraman, under the pressure of production were obliged to shoot scenes with an incorrect illuminant, a single dot on a graph would tell the laboratory the nature and amount of the deviation to be expected.

An instrument incorporating the logarithmic scales described here for the blue–red and green–red values is shown in Fig. 11.

Much work remains to be and will be done on the system herein described. In the meantime, it has seemed to us that the results are sufficiently promising and interesting to warrant publication and availability for discussion at this time.

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The Stroboscope as a Light Source For Motion Pictures

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SUMMARY: The stroboscope has long been proposed as a source of illumination for ordinary motion pictures because of several attractive technical features; however, as has been pointed out clearly by F. E. Carlson[1] recently, there are serious disadvantages that must be overcome before the flashtube finds widespread practical use for everyday motion picture studio photography. This study reports additional experiences with flashtubes especially at large power input as would be needed in picture taking. One object was to find the upper power limitations of existing commercial flashtubes. A further object was to study the design and performance of a three-phase efficient power supply.

Motion picture studio lighting has been a challenging problem for electrical engineers especially since the advent of sound and color photography. There is still need for improved light sources and it is this urge which has prompted the effort reported in this paper.

The theory of flashtubes and circuits has been described in several articles given in the bibliography[2–4] and therefore will not be repeated here.

First, it is in order to discuss briefly the advantages that are inherent in the stroboscopic system of illumination:

1. The flashes of light occur only while the camera shutter is open, resulting in 100% utilization of the light. A conventional camera with continuous light uses only about 50% of the light. Thus a doubling of efficiency is possible.

2. The light-producing efficiency of Xenon-filled electronic flashtubes is higher than tungsten lamps.

3. The effective color temperature of Xenon tubes is almost the same as for daylight. Therefore the same camera and film equipment can be used for outdoor and studio photography.

The main disadvantages of the stroboscopic system are:

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1. The flicker of the light at 24 cycles (one flash per frame) is unbearable by the actors. It has been proposed that multiple flashes be used to avoid this difficulty. Another possible solution is to use a combination of continuous and flashing lights.

2. The short flash of the stroboscopic source produces a clear sharp photograph of a rapidly moving subject instead of the desired blurred image.

3. There is a certain amount of noise associated with a powerful stroboscopic source that may be objectionable on sound stages. Acoustical treatment will be necessary for the tubes.

This paper is concerned with the design of powerful 24-cycle stroboscopic sources using existing tubes with the thought that the advantages of the system will make the system useful, regardless of the disadvantages, for special applications.

FLASHTUBES FOR STROBOSCOPIC SOURCES

The practical upper power limit for a flashtube operated as a stroboscope is considerably different than when operated for single-flash photography. Some of the important factors influencing tube design and use are discussed in the following.

Flashtubes when used for single flashes at remote intervals of time are not concerned with the over-all temperature of the tube. The inner surface of the tube is influenced by the transient temperature pulse but the average temperature does not rise to a point where performance is influenced. One of the upper limits of energy that can be put into a flashtube in a single flash depends upon the surface temperature conditions. With a glass tube, an overload will result in a crazed surface consisting of a network of surface cracks. With a quartz tube, the overload will be several times greater for the same internal dimensions and will produce a cloudy appearance which is apparently caused by condensed quartz vapor that has been evaporated by the energy from the flash. Experiments show that the light output is not materially reduced for both glass and quartz tubes even after serious crazing or cloudiness; however, the life of such tubes may be greatly reduced.

It is very important in single-flash work to load the flashtube as high as possible in order to enjoy the resulting high efficiency; therefore an effort is made to load single-flash tubes to a maximum.

For continuous stroboscopic use, it is not possible to load the tubes since the average temperature of the tube walls will become excessive. A glass tube exhibits wall conduction when it becomes hot. The trigger electrode potential in some cases will cause a puncture of

the hot glass wall allowing the entrance of air and thereby ruining the tube. In other cases the conduction by the hot glass effectively short circuits the spark excitation, resulting in flash missing. The quartz tubes exhibit similar characteristics except the failures exhibit themselves at a much higher temperature. Puncture of a quartz tube by the excitation is a rather rare event compared to skipping, while with a glass tube the opposite is the general case. A skipping quartz tube

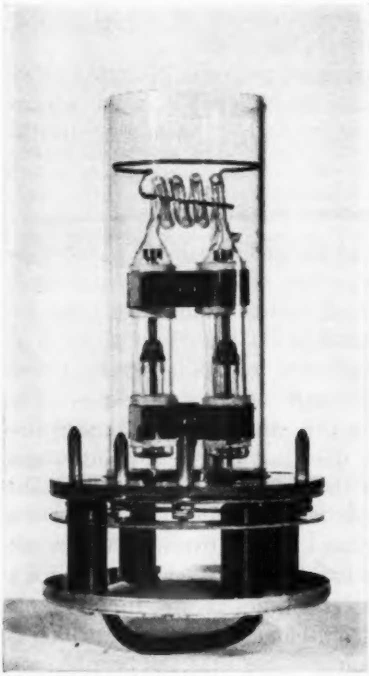

Fig. 1. General Electric quartz flashtube No. FT-417.

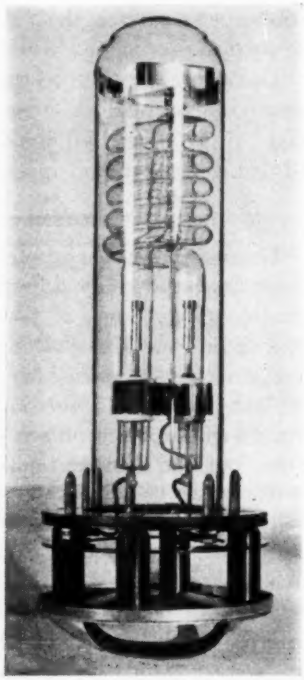

Fig. 2. General Electric quartz flashtube No. FT-623.

is usually not damaged. It can be made to operate satisfactorily by reducing the power input or by artificial cooling with air or water.

Another limiting factor for stroboscopic tubes is electrode temperature. For single-flash applications the electrodes can be small; however, for stroboscopic use, the area must be increased to radiate the continuous electrode losses.

Flashtubes such as the FT-503 and FT-524 (General Electric Co.) have a quartz spiral but small electrodes limit the input to about

700 w since with that input the electrodes reach a yellow heat. Additional continuous input will result in excessive electrode evaporation and other objectionable characteristics. A flow of air is required also for 700-w input to cool the quartz spiral and the FT-524 tube is especially designed for this with an open end so that a draft of air can be forced directly through the tube. These tubes were not studied since their output was so small.

Two quartz flashtubes are available which have a larger electrode assembly which is capable of handling greater power. These tubes are the FT-617 and the FT-417 (Fig. 1), both General Electric Co. products. Flashtube No. FT-617 is the same as No. FT-623 (Fig. 2) except that the glass envelope is open to facilitate cooling. An uncoiled version of the FT-417 is also available from General Electric Co. and is identified as the FT-427. Approximate dimensions of the helical tubes follow:

	Helix diameter, in.	Helix length, in.	Number of turns	Tubing, outside diameter	Gas
FT-417	$1\frac{1}{8}$	$1\frac{3}{8}$	4	$\frac{1}{4}$	Xenon
FT-617	$2\frac{9}{16}$	3	5	$\frac{1}{2}$	Xenon

The electrodes of both tubes consist of a sintered pellet of tungsten, nickel and barium, welded to a $\frac{1}{4}$-in. solid iron post about 1 in. in length.

The actual tubes used in our tests were an earlier variation of the FT-617 and had a spiral of six turns instead of five. Likewise the FT-417 tube used here was an early experimental type which may be slightly different from production tubes. However it is thought that the results from these tubes will be comparable to the tubes currently available. No experiments have been made to determine the life under the conditions reported here. Our results should be

Table I. Efficiency Data

Tube	*V*, volts	*C*, microfarads	Energy, watt-sec	Light, lumen-sec	Efficiency, lumen-sec/watt/sec
FT-214 Std.	2150	101.17	235	7550	32.1
FT-417	2150	130	300	8800	29.3
	2150	101.17	235	6650	28.3
	2150	50.7	117	2870	24.5
FT-617	2150	130	300	5750	19.2
	2150	101.7	235	4500	19.2
	2150	50.7	117	2250	19.3

considered to be preliminary and should be checked with production tubes.

The efficiency data for the two tubes under conditions as used in stroboscopic circuits are shown in Table I.

It has been found that each given type of tube can be operated at some experimentally determined maximum power input for given cooling conditions. In terms of the circuit this power is approximately

$$P = \frac{CE^2}{2} f \text{ watts input}$$

where C = capacitance in farads,
E = voltage to which the capacitance is charged prior to the flash in volts, and
f = the frequency of flashing in flashes per second.

Once the maximum power is known and the frequency selected, then the watt-seconds loading $CE^2/2$ is fixed. Likewise the efficiency is determined as given by the characteristics of the flashtube.

An important conclusion from the above that bothers the designer of a stroboscope is the decrease of possible efficiency with an increase of frequency when the power is constant. The importance of the use of quartz and forced cooling is apparent since both permit a higher power input and therefore the tube operates at a higher efficiency.

Without forced cooling, both the FT-617 and the FT-417 are limited in continuous stroboscopic operation by the heating of the quartz tubing. The FT-617 with its large-area coil structure is easy to cool with a blast of air through the tube. The FT-417 does not cool so easily since the air flow is not uniform around its small coil. Hot spots tend to develop on the opposite side of the tube from where the air is blown. These can be seen since the quartz reaches a red heat.

The FT-617 tube cannot be operated with a power input greater than 4 kw even with an unlimited air blast since the electrodes reach a temperature where holdover tendencies are in evidence. Furthermore the electrodes tend to evaporate and discolor the tube.

The FT-417 is likewise limited to 4 kw because of the electrode structure. Cooling of the quartz spiral on the FT-417 is more of a problem than on the FT-617 because of difficulty of getting adequate heat transfer. A few experiments were made with the FT-417 coil immersed in water. The operation was satisfactory even with 10-kw input for short bursts with electrode heating again being the limiting factor.

Intermittent use of a stroboscope can be accomplished at higher power inputs than when used continuously. For example an earlier version of the FT-617 tube discussed later which operated continuously at 4-kw input could be run for 30 sec with 10 kw before the electrodes reached an excessive temperature.

POWER SUPPLY DESIGN AND TUBE PERFORMANCE

The design of a power supply to operate a stroboscope tube with an input of 4 to 10 kw requires some special considerations. For example, if a single-phase a-c circuit is used, the power supply would need to have filter capacitors to smooth out the ripples which might cause nonuniformity of the light flashes.

The preferred method of supplying power from an a-c distribution system for power values over about a kilowatt is the use of the conventional three-phase system. This type of system was used for a

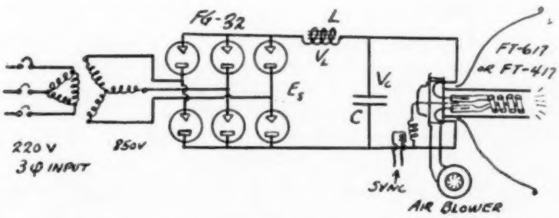

Fig. 3. Three-phase power supply to operate a flashtube at 10-kw input.

power source here with a six-phase rectifying system which has a rather small ripple. In fact with the choke charging system shown, there is no need for a capacitor filter.

Figure 3 shows the diagram of the power supply which was used. This 1000-v supply can deliver 10 kw to a stroboscope lamp at 2000 v.

Power can be purchased from the power company at the proper voltage (about 850 v) to supply the rectifiers and flashtube. In this way the cost of transformers is eliminated from the power supply equipment at a considerable saving in expense and weight.

The six-phase rectifier system reported here shows mercury vapor rectifiers, General Electric Co. type FG-32. Serious consideration should be given to selenium rectifiers for this service since the filament-heating delay complications would be eliminated. At present the selenium system would cost more than tubes but would have operational advantages that might justify the extra investment.

The size and thereby the cost of the charging inductor is deter-

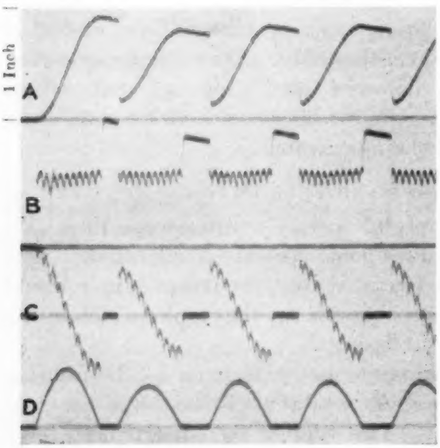

Fig. 4. Voltages and current in charging circuit during flashtube operation at 24 flashes/sec. $L = 1.62$ h; $C = 46$ μf.

KEY to Figs. 4, 5 and 6:

Time scale: 1 in. = 0.08 sec. (See legend beside Fig. 4 above.)
A. $V_c(t)$, storage capacitor and flashtube voltage, 1 in. = 3,780 v.
B. $E_s(t)$, rectifier output voltage, 1 in. = 3,000 v.
C. $V_l(t)$, charging inductor voltage, 1 in. = 3,220 v.
D. $i(t)$, charging current, 1 in. = 19 amp.

mined by the transient watt-second storage capacity. As will be shown later this energy is one-fourth that of the discharge capacitor. In our preliminary design investigations, we found that the inductor might weigh more than the capacitor. A further engineering study is required to arrive at the best design of the inductance.

The power transformer, if used, can be built with leakage reactance that can supply all or part of the inductive component of the circuit.

The flashtube energy storage capacitor C (Fig. 3) is charged to approximately twice the rectifier output voltage, through the charging inductor L. The capacitor holds the voltage because the rectifiers prevent a current reversal until the flashtube is triggered. When the flashtube is ionized, it breaks down and discharges the capacitor to the relatively low voltage at which the flashtube becomes nonconducting. The capacitor then recharges through the inductor, completing the cycle.

Figure 4 shows oscillographic records of the current and voltage relations in the charging circuit during repetitive operation at 24 flashes/sec, with a storage capacitor of 46 μf (microfarads) and a charging inductor of 1.62 h (henries). The rectifier output voltage has a ripple with six times the frequency of the supply voltage, caused

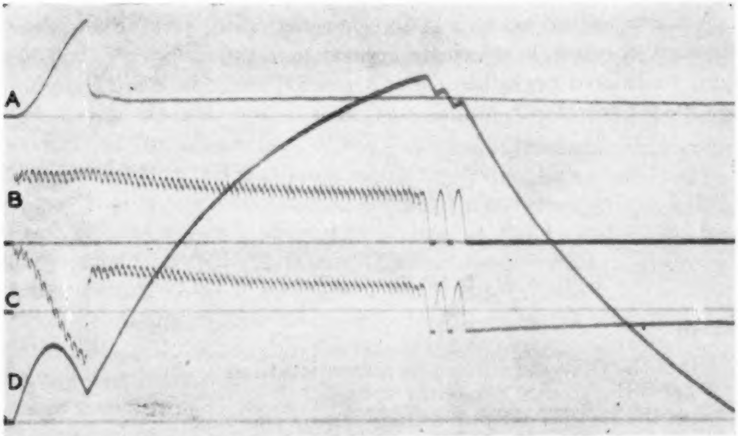

Fig. 5. Voltages and current in charging circuit, showing flashtube hold-over during first pulse of charging current. $L = 1.62$ h; $C = 94\ \mu$f.

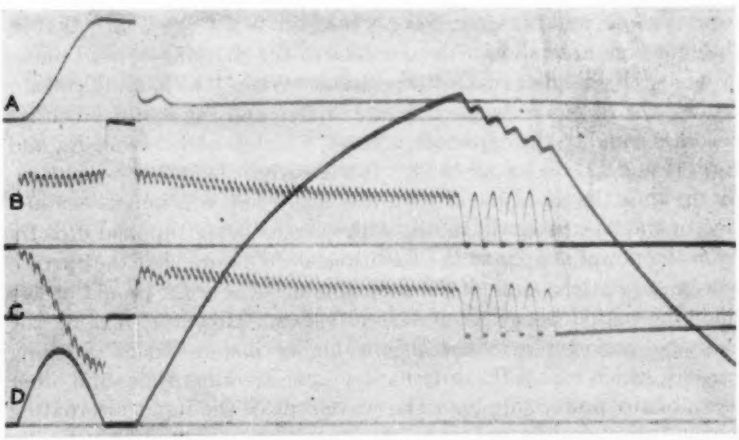

Fig. 6. Voltages and current in charging circuit, showing flashtube hold-over during second pulse of charging current. $L = 1.62$ h; $C = 94\ \mu$f.

by the full-wave, three-phase rectification. The first pulses of current and voltage are larger than succeeding pulses, because the first charging cycle starts with the capacitor initially uncharged. The slight drop in the capacitor voltage after it reaches a maximum is caused by the drain of the oscillograph element and multiplier.

A mathematical analysis of the charging circuit yields the expressions given below, in which the resistance of the charging circuit has been considered negligible. For a general analysis of d-c charging, see *Pulse Generators*.[5]

$$i(t) = \frac{E_s - V_c(0)}{\sqrt{L/C}} \sin \sqrt{1/LC} \quad t \qquad (1)$$

and

$$V_c(t) = E_s + [V_c(0) - E_s]\cos \sqrt{1/LC} \quad t \qquad (2)$$

where

$i(t)$ is the charging current as a function time, t,
$V_c(t)$ is the storage capacitor voltage,
E_s is the rectifier output voltage during charging,
$V_c(0)$ is the capacitor voltage at the beginning of a charging cycle,
L is the charging inductance in henries,
C is the energy-storage capacitance in farads, and
$t = 0$ is the beginning of a charging pulse.

Equations (1) and (2) are valid only between $0 \leqq t \leqq \pi\sqrt{LC}$; that is, the equations are valid for the duration of the charging-current pulse, or while the charging current is positive. When the charging current is zero, the drop across the inductor is zero and the rectifier voltage becomes equal to the capacitor voltage, which is about twice E_s, and Eq. (1) and (2) no longer hold. If the current has not become zero by the time the flashtube is fired, it is likely that continuous conduction of the flashtube will result, with current being supplied directly from the power supply to the flashtube. To assure that the current will be zero at the time of the flashtube firing, $\pi\sqrt{LC}$ should be less than the period between successive flashes. However, making the charging period very short means higher instantaneous charging current, which makes the duty harder on the rectifier tubes and other parts of the power supply. The waveform of the input alternating current also becomes poorer as the charging time becomes a smaller fraction of the period between flashes.

From Eq. (1) and (2), it is noted that the maximum value of charging current is

$$I_{max} = \frac{E_s - V_c(0)}{\sqrt{L/C}} \qquad (3)$$

and the maximum capacitor voltage is

$$V_{c\,max} = 2\,E_s - V_c(0) \qquad (4)$$

Equations (3) and (4) are useful in predicting two quantities of primary concern in the design of the power supply: maximum charging current and maximum or final capacitor voltage.

From Eq. (3) it is obvious that the maximum current should vary inversely as the square root of the charging inductance. Equation (4) indicates that the maximum capacitor voltage is not affected by changes in charging inductance. A change in the storage capacitance affects the maximum current the inverse of the way a change in charging inductance does; that is, the maximum charging current increases directly as the square root of the storage capacitance.

In the charging circuit, the inductor must be capable of storing the energy $LI^2_{\max}/2$. Changing the size of the inductance will not alter the required energy-storage capacity of the inductor, since $I_{\max}$ increases inversely as the square root of L. The required energy-storage capacity of the inductor is

$$LI^2_{\max}/2 = \left[\frac{E_s - V_c(0)}{2E_s - V_c(0)}\right]^2 \frac{CV^2_{c\max}}{2} \tag{5}$$

From Eq. (5) it is seen that on the initial charging pulse, since $V_c(0)$ is zero, the peak energy storage in the inductor is one-fourth of the final energy storage in the capacitor, but is less than one-fourth on succeeding pulses, when $V_c(0)$ is not zero.

To summarize the requirements of a charging inductor:

1. The peak energy-storage capacity of the inductor must be at least one-fourth the final energy storage of the capacitor.

2. For a given amount of capacitance, the inductance should not be so large that $\pi\sqrt{LC}$ exceeds the period between flashes.

3. The inductance should not be so small that the charging time is too short in comparison with the period between flashes. Low inductance, besides increasing the severity of the duty on circuit elements, is less effective in isolating the flashtube from the power supply immediately following the flash.

Besides the above considerations, an economical inductor design must take into account the proper balance of copper, iron, air gap and insulation. Of course, if one inductor is to be used over a range of flashing rates or capacitances, optimum design over the whole range is not possible, and some compromises must be made.

The oscillograms of Figs. 5 and 6 illustrate two conditions that lead to holdover, or failure of the flashtube to stop conducting. In Fig. 5, the flashtube was flashed before maximum voltage and zero charging current occurred. Since there was a current flowing in the inductor at the time of flashing, it continued to flow through the flash-

tube, being limited only by the charging inductance, until finally the circuit breakers opened.

In Fig. 6, the current had gone to zero, following the charging of the capacitor to full voltage. The flashtube was flashed, and the normal build-up of current and capacitor voltage had begun when apparently the flashtube "broke down" again, and a holdover similar to the one in Fig. 5 occurred. The breakdown of the flashtube was probably caused by failure of the inductor to provide isolation from the power supply long enough for complete deionization of the flashtube to take place. With the FT-617A, it was impossible to prevent holdover by increasing the size of the inductance when the input was above about 4 kw at 24 flashes/sec, with flashtube voltage at 2,000. The inductance was increased to the limit at which $\pi\sqrt{LC}$ was just below the period between flashes, and holdover still occurred occasionally.

With the FT-417, no trouble was experienced with holdover even when loaded to 10 kw. This is attributed largely to the fact that the smaller tube had a much shorter deionization time than the FT-617A. Deionization after conduction is the result of ion and electron recombination mainly on the inner surface. Since the ratio of surface area to volume increases when diameter decreases, the smaller tube should become deionized more readily.

Two related problems that are of considerable importance are those of flashtube cooling and flashtube starting, or triggering. When the flashtube becomes too hot, the insulating property of quartz becomes very poor, and the starting pulse—instead of ionizing the gas—is shunted around the gas by the quartz tubing, and the flashtube fails to fire. With the FT-617, this is easily remedied by using a small air blower for forced air-cooling. Whereas the flashtube could be operated without cooling at a power input of $1\frac{1}{2}$ kw for 1 min, or at 4 kw for 30 sec, with forced air-cooling it could be operated continuously with an input of 5 kw, except for the holdover problem at this input.

The smaller FT-417 heated up more rapidly and would not operate for more than about 20 sec at 5-kw input, even with very strong forced air-cooling.

An interesting experiment in water-cooling was performed with the FT-417. It ran smoothly with an input of 10 kw while the whole flashtube, except for the main electrode lead-in wires, was submerged in water. The flashtube would apparently fire regularly for as long as desired. However, the electrodes became white-hot in about 30 sec at this input. After a total flashing time of about 2 min at this input, the flashtube showed several signs of hard use. The electrodes

were blackened and pitted, and some of the metal had sputtered to the adjacent quartz tubing. The inside of the quartz tubing was clouded considerably, presumably caused by a melting or vaporization of the quartz on the inside of the tubing. This experiment indicates the possible practicability of using a water-cooled flashtube, though of course there would be numerous problems connected with the design of such a flashtube.

THE FLICKER PROBLEM

A major problem with the use of stroboscopic sources when people are illuminated is the flicker effect. Intermittent 24-cycle light is very disturbing.

A brief investigation was made to determine the possibility of relieving the flicker effect by supplementing the stroboscopic light with some continuous light. It was found that the ratio of continuous light from a tungsten lamp to stroboscopic light, for almost complete elimination of the flicker effect, was about 10 to 1. For a basis of comparison, the light output in lumens for the stroboscopic source was taken as 24 times the lumen-seconds per flash. With this ratio of continuous to stroboscopic light of 10 to 1, the usually observed stroboscopic effects—such as the apparent change in speed or direction of rotation of wheels, jerkiness of movements, and flickering of light—were hardly detectable. However, at ratios of about 8 to 1 and lower, the stroboscopic and flicker effects were only slightly less than when only the stroboscopic source was used.

The problems of flashtube noise and the excess blue of the flashtube light output will also have to be met in using flashtubes in movie work. Some noise reduction may be obtained by tube design and by using an inductance in series with the flashtube. For color correction for daylight-type Kodachrome film, a CC13 or CC15 filter is recommended. It may be that a proper mixture of stroboscopic lighting and continuous lighting would make the use of filters unnecessary.

Another method of reducing flicker is to increase the flashing rate. To do this reduces the efficiency as has been pointed out before.

CONCLUSIONS

The upper limit of power input to a flashtube is determined by the thermal capacity of the flashtube. If the quartz tubing becomes too hot, the flashtube fails to fire and the tubing may be damaged; if the electrodes become too hot, they may be damaged and the flashtube tends to hold over more readily. Which of the factors is the limiting

one depends upon the tube and electrode design, the circuit design, the method of cooling, and the length of time that operation is desired.

Once the maximum power input is determined for a given tube, circuit and cooling, it will be essentially constant regardless of frequency. Then, since power input is a function of input per flash and flashes per second, the permissible input to the flashtube for each flash will depend upon maximum power input and the rate of flashing, or $CV^2/2 = P_{max}/f$ watt-seconds per flash.

The stroboscopic flashtube unit described here when operated with the FT-617, with a storage capacitance of 74 μf charged to 2,000 v, will operate continuously at a flashing rate of 24 flashes/sec, with forced air-cooling from a 35-w, 8,400-rpm blower; operation for about 30 sec is possible with no forced air-cooling. The power input to the system is about 3.6 kw, and the energy per flash is about 150 w-sec.

The light output is 2,600 lm-sec/flash, since the efficiency is about 17 lm/w. If the flashtube is placed in a reflector with an efficiency of 10, it produces 104 lm/sec/sq ft at a distance of 5 ft. This amount of light is sufficient for photography with daylight-type Kodachrome film at *f*/3.5, and considerable coverage could be obtained with several such flashtubes. However, it is obvious that increasing the flashing rate means cutting the watt-seconds per flash in order to stay within the power rating of the flashtube. For example, if the flashing rate in the above case were increased to 48 flashes/sec, the energy input per flash would have to be cut in half, or to 75 w-sec/flash. The light output would be cut by more than half, since the efficiency would be lowered.

Thus it seems that in order to get a flashtube source more useful for movie photography, it will be necessary to increase the thermal capacity of flashtubes so that they can be operated repetitively at higher loadings and higher efficiencies. One possibility is a water-cooled flashtube. Another is a tube with large electrodes.

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Study of Sealed Beam Lamps For Motion Picture Set Lighting

By WAYNE BLACKBURN

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SUMMARY: Limitations and advantages of sealed beam lamps for motion picture set lighting are disclosed. Comparisons of light output and distribution vs. regular studio spot lamps are made; also, lamp efficiency, life and weight of equipment are discussed. Lamp requirements for motion picture set lighting are presented and the methods followed by the Motion Picture Research Council to determine possible usage of sealed beam lamps are described.

For some time, many people associated with motion picture set lighting have thought the incandescent lighting equipment now being used appeared heavier and more bulky than necessary. The recent strict budgets have accelerated the exploration for a simple light source and flexible lighting equipment. Attention was drawn to the sealed beam type of lamp having a built-in reflector. This type of lamp is presently being used primarily for fill light on locations and was used for television studio lighting as early as July, 1939.[1]

The amount of illumination obtained from this type of lamp, such as the reflector photoflood (RFL-2) and reflector spot (RSP-2) (see Fig. 1), is very impressive. Such lamps have an average life of 6 hr and dissipate 500 w. This lamp construction and operation will supply more light per watt to the studio set than present spot lamps, but the fixed focus design sacrifices the ability to spot or flood the light beam.

The Colortran Converter Co., Hollywood, Calif., supplies to the industry portable kits in which long-life industrial lamps are used. These lamps are operated at an elevated voltage by transformer action. So operated, these industrial lamps have a light output, color temperature and life comparable to photofloods. Such tactics increase lamp efficiency since light output increases approximately twice as fast as the wattage when the melting point of the tungsten filament is approached (see Fig. 2).

This Colortran equipment is very popular with the studios, especially for location work where close shooting quarters, power consump-

[1] William C. Eddy, "Television lighting," *Jour. SMPE*, vol. 33, pp. 41–53, July 1939.

Presented: October 11, 1949, at the SMPE Convention in Hollywood.

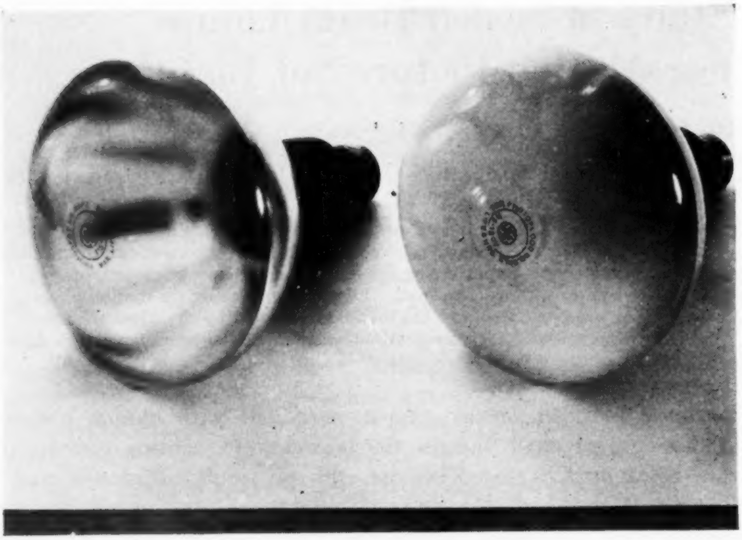
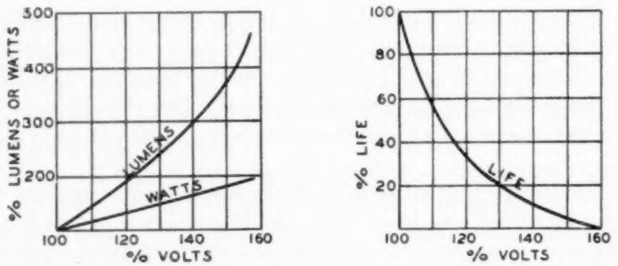


Fig. 1. Reflector Spot (RSP-2) and Reflector Flood (RFL-2); 500-w, 6-hr life.



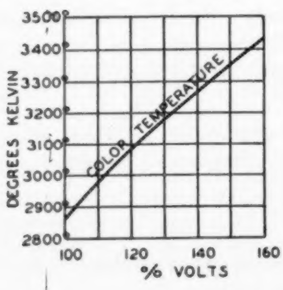


Fig. 2. Characteristic curves of standard 120-v, 1,000-hr life, incandescent lamps when operated at other than the rated voltage.

tion and portability are important considerations. The industrial 150-w PAR-38 flood (Fig. 3) appears to be the most suitable lamp for this equipment.

Due to the interest shown in reflector-type lamps, the Motion Picture Research Council studied the characteristics of such lamps to see if over-all advantages existed which would make them more economical for studio use. Existing built-in reflector lamps were measured and compared with present equipment (see Table I). Light measurements were made at the center, edge and 6 deg outside a circle $8\frac{1}{2}$ ft in diameter, located 20 ft from the light source.

It is interesting to compare the 500-w reflector flood (RFL-2) operating at 120 v with the PAR-38 flood operating at 185 v. Under these operating conditions, the lamps have comparable life. Inside the circle, the PAR-38 delivers twice as much light as the RFL-2. The RFL-2 has a more uniform field of illumination, but the fall-off of the PAR-38 is not considered too serious. Outside the circle, the RFL-2 delivers considerably more light. In general, however, this outside illumination is undesirable and will be masked off with barndoors* or gobos† unless the lamp is being used to supply fill light.

Photographic tests were made at Paramount Studios to determine whether acceptable black-and-white picture quality could be obtained using only reflector-type lamps. Colortran transformers were used for over-voltage operation. Identical long shots and close-ups with the same light key and at the same lens stop were taken; first with standard lighting equipment and then repeated using sealed beam reflector-type lamps only (Fig. 4). Well-known cinematographers, professional players, a dressed set and the recording of sound were used. Equivalent and highly satisfactory photography was obtained using barndoors, scrims and gobos, in spite of the fact that sealed beam lamps are diffused light sources. The sealed beam lamps required approximately one-third the wattage of that of standard lighting. Less time was required to make setups using the sealed beam lamps. However, a fair comparison cannot be made because the studio lamps were set up first and lamp placement had already been determined when the sealed beam lamps were set up. Individual dimming was supplied to each sealed beam lamp through a small variable resistor. The sealed beam lamps had a higher color temperature, although the foot-candle reading was kept the same for both types

* Black, movable extension doors hinged on lamp housing to restrict light from reaching certain areas.

† Normally, cloth masks of various sizes, mounted separately from lamp housings, used to block light from certain areas.

TABLE I. Test Results of Light Output

					Light Distribution*		
Description	Volts	Watts	Life Hours	Color Temp., °Kelvin	Center foot-candle	Edge foot-candle	2 Ft† outside circle
From Commercial Sealed Beam Lamps							
RFL-2..........	120	500	6	3400	20	17	16
RSP-2..........	120	500	6	3400	130	60	23
150 PAR-38/FL.	120	150	1000	2800	11	8	6
150 PAR-38/FL.	155	225	*63*	*3100*	22	18	13
150 PAR-38/FL.	185	292	*6*	*3340*	46	33	23
150 PAR-38/SP.	120	150	1000	2800	29	7	3
150 PAR-38/SP.	175	267	*7*	*3260*	100	25	11
150 R-40/FL....	120	150	1000	2800	3	1	½
150 R-40/FL....	175	267	*7*	*3260*	12	9	7
150 R-40/SP....	120	150	1000	2800	14	8	2
150 R-40/SP....	175	267	*7*	*3260*	53	12	7
300 R-40/FL....	120	300	1000	2800	6	5	3
300 R-40/FL....	175	535	*7*	*3260*	22	18	14
300 R-40/SP....	120	300	1000	2800	40	13	5
300 R-40/SP....	185	585	*3*	*3340*	160	45	13
4560†...........	28	600	25	3300	1260	72‡	—
750 R-40........	120	750	6	3400	165	37	20
500 R-40........ (Frosted)	120	500	750	2800	15	12	10
500 R-40........ (Frosted)	165	810	*7*	*3175*	41	32	26
500 R-40........ (Clear)	120	500	750	2800	21	27	20
1000 R-80....... (Clear)	120	1000	750	2800	17	10	16
1000 R-80....... (Frosted)	120	1000	750	2800	17	17	16
1000 R-80....... (Frosted)	155	1500	*37*	*3090*	38	38	37
Present Studio Lamps, for comparison							
500 MP.........	120	500	35	3200	31	24	12
500 MP.........	135	600	*8*	*3325*	43	34	16
500 CP.........	120	500	8	3350	32	24	12
750 MP.........	120	750	30	3200	45	37	18
750 MP.........	135	900	*7*	*3325*	63	52	26
750 CP..........	120	750	12	3350	48	39	20
1000 MP........	120	1000	35	3200	60	50	22
1000 MP........	145	1340	*6*	*3410*	108	87	30
2000 MP........	120	2000	100	3250	118	94	32
2000 MP........	145	2680	*8*	*3460*	210	165	95
2000 CP........	120	2000	25	3350	125	100	41

See notes on following page.

of lighting. This increase of energy in the blue region of the spectrum increased the actinic value so that a negative of higher density was obtained with the sealed beam lamps. Thus, to match print density from the two negatives, it was necessary to print two light steps higher with the negative using sealed beam lamps. Rigging and striking time was reduced because the lamp housings weighed only a fraction of the weight of standard equipment.

With evidence that satisfactory photography could be obtained with sealed beam lamps, the lamp manufacturers were requested to provide special lamps for experimental work. Special filaments in existing bulbs of various sizes were supplied. These lamps were life tested and the rate of aging was measured for different filament orientations.

Of these experimental lamps, the PAR-38 flood bulb with a 115-v, 500-w, CC-6 filament seemed the most desirable for our application. Life tests indicated that an average life of 6 hr could be expected. Damage of the reflector was observed directly about the filament during life tests, but had no serious effect. The lamp delivered over three times the amount of light of a 500-w RFL-2 in the 8½-ft-diameter circle and approximately 75% of the light of a 2,000-w studio Junior spot lamp.

To realize fully the possible advantages of sealed beam lamps for studio use, the Research Council designed housings, associated equipment and scaffolds to accommodate PAR-38 or R-40 bulbs. Figure 5 shows the lamp housing and the adjustable scissor bracket in the retracted position. Figure 6 is a multiple exposure showing possible positions of the scissors. Figure 7 is a small set rigged with this special lamp equipment. Figure 8 shows the type of scaffold used, which is supported entirely by the set walls.

Individual electrical dimming of the lamps can be done either from a master control board located on the stage floor, or with a rheostat located on each housing and operated at the lamp. Remote control on a master board affords quick lamp adjustments for the gaffer (chief set electrician), but entails the numbering of each lamp and the running of cables from the lamps to correspondingly numbered controls

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NOTE: Underlined figures of *life* and *color temperature* are calculated for an average lamp and subject to considerable variation for an individual lamp.

* Measurements made in standard studio lamp housings flooded to 20% reduction in lamp beam candlepower at edge of circle 8½ ft in diameter, 20 ft from lamp; this is to simplify comparison with reflector lamps.

† Airplane landing lamp.

‡ 6° from center.

Fig. 3. PAR-38 Flood; 150-w, 1,000-hr life.

Fig. 4. Master long shot using sealed beam lamps.

at the master board. Having a rheostat on each lamp housing provides a much simpler wiring setup, but requires manual dimming at the lamp by the operator. Choice between these two methods will be determined largely by operating experience.

Sealed beam lamps are not capable of producing the sharpness of shadows obtained with regular studio lamps. This has been cited as a handicap by the cinematographers, although as shown by our Paramount tests, it is not a requisite for pleasing photography. The cameramen claim the difficulty lies in obtaining an apparent pictorial separation of the subject from the background by producing a brightness

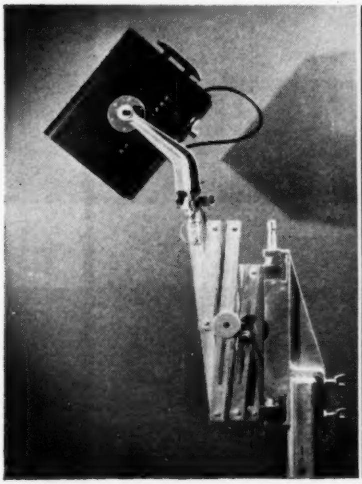


Fig. 5. Lamp housing and the adjustable scissor bracket in the retracted position.

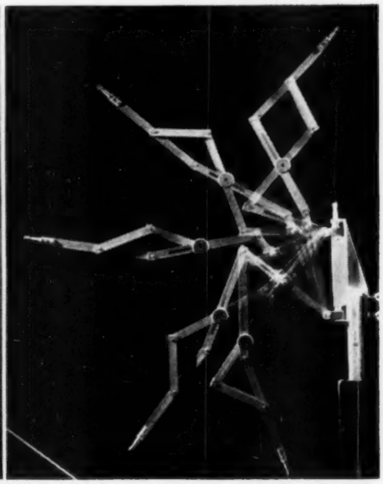


Fig. 6. Multiple exposure photograph showing movement of the scissors.

difference. This decrease in shadow sharpness is due to the increase in apparent light source size. For example, the entire area of the lamp face of the popular photoflood (RFL-2) is the apparent light source. Therefore, when half of the lamp face is covered, no shadow is produced on the corresponding side of the set, but only a general reduction in total illumination results. Each section of the face of a regular studio lamp supplies light to a different area in the set; that is, the top portion of the lens face supplies light to only the top area of the set and therefore can be conveniently masked near the lamp. This permits an actor to be properly illuminated, and then by masking

Fig. 7. Small set rigged with housings and scissors.

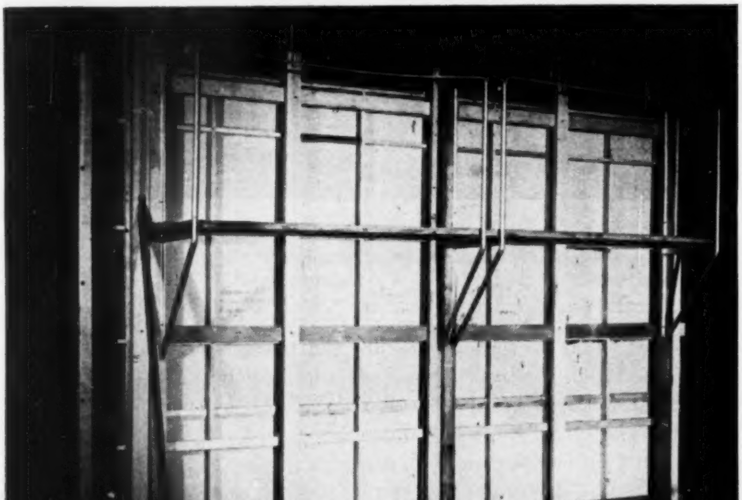


Fig. 8. Scaffold hangers supported by set walls.

the outer portion of the lamp face, casts a corresponding shadow close to the actor without affecting the amount of illumination on the subject.

Tests were made to determine in what way and to what extent sealed beam lamps deviate from a point source. This was done by masking off the face, except for a hole 1 cm in diameter (0.4 in.). The 1-cm hole was permitted to transmit light at various points located from the center out to the edge of the lamp. The plots of a typical reflector lamp and a regular studio lamp are shown in Figs. 9A and 9B.

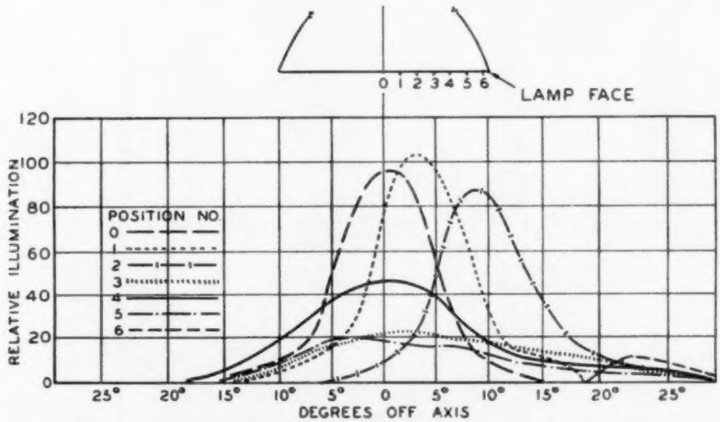


Fig. 9A. Distribution of light from small circular areas (1-cm diam.) of lamp face of PAR-38 Flood.

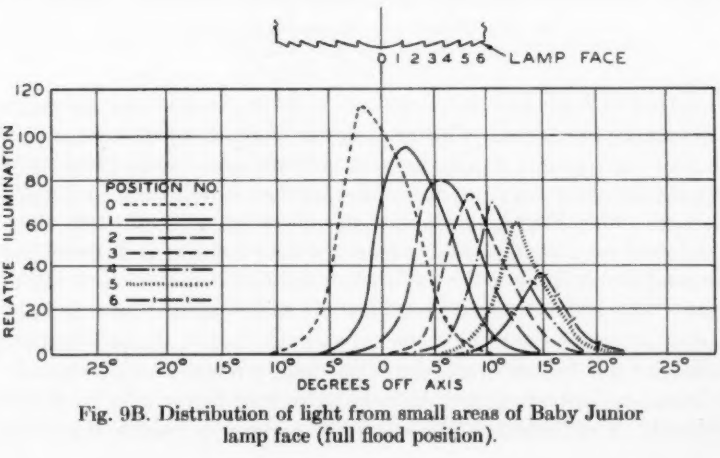


Fig. 9B. Distribution of light from small areas of Baby Junior lamp face (full flood position).

Fig. 10A. Taken with Studio Baby Junior;
lamp placed 6 ft from subject.

Note that with the reflector lamp, any point in the field sees the entire large source area, while with the regular studio lamp the outer portions of the lens-face supply light to only the outer areas of the field and not the entire field area, thus meeting the requirements for a sharp shadow. This effect is pictorially shown in Figs. 10A and 10B. The facial shadows and the shadows from the door molding and door blind are comparable using either the studio baby Junior spot or the PAR-38 flood. But where object and shadow are widely spaced, such as head to shadow on the door blind, the baby Junior casts a sharper shadow. Note that the shadow break above the door, produced with barndoors on housings, is much sharper with the baby Junior than with the PAR-38 flood. This indicates that if an improvement in shadow sharpness

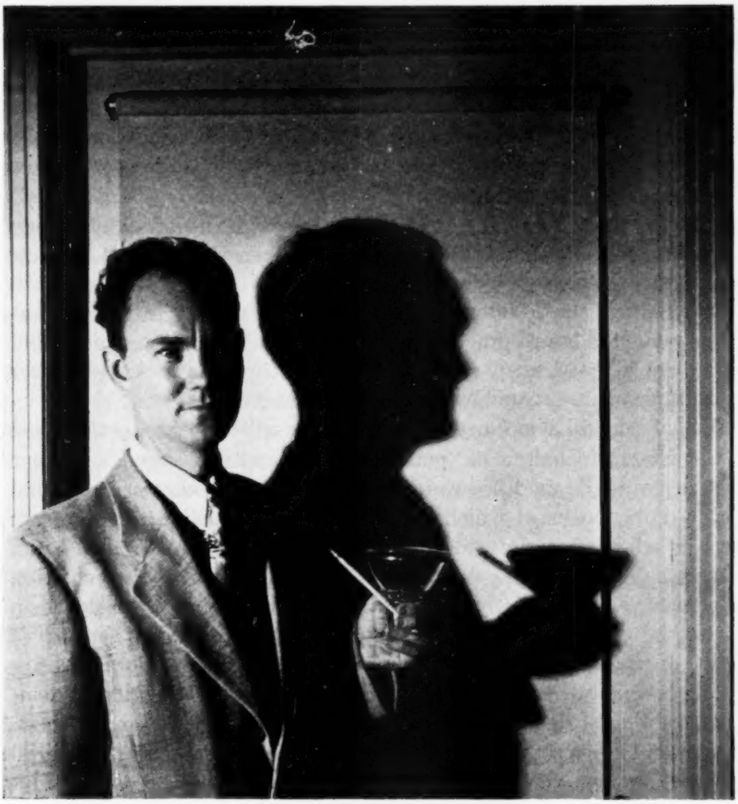


Fig. 10B. Taken with PAR-38 Flood in Research Council housing; lamp 6 ft from subject.

is to be obtained with sealed beam lamps, the face of the lamp must be masked to reduce the apparent source size.

Various types of louvers were tried in front of the lamp face to reduce the apparent source size. In general, the light distribution was badly distorted or confined, with loss in light output. An open rectangular slit kept parallel to the barndoors was found to be the best compromise, but the loss of light output makes the use of louvers questionable.

It should be stated that from a practical standpoint the apparent source size of a sealed beam lamp cannot be reduced by the use of a lens face, such as a Fresnel. This is due to the fact that the filament

size and focal length of the reflector are the determining factors of source size. Light output and size make it impractical to change the lamp design.

Sealed beam lamps should be given serious consideration for use in set lighting. Although, as outlined above, sealed beam lamps are different in many respects than present studio incandescent lamps, they have distinct advantages.

To summarize, sealed beam lamps supply light at a high efficiency and are small and lightweight. For example, a 500-w, PAR-38, 6-hr lamp with a Research Council housing weighs 7 lb and delivers 75% of the light of the 2,000-w Studio Junior weighing 39 lb. Such features make the lamps practical for location work in existing homes and buildings where transportation, close shooting quarters and power consumption are extremely important considerations.

Use of sealed beam lamps for stage work will save production time if the present technique of "painting" with light is changed. Present practice must be modified as it calls for a given number of individual light sources, each of which lights an assigned portion of the scene; each is adjusted, scrimmed and masked to do its job. Sealed beam lamps have no unique value if so applied. However, production time can be substantially reduced by the efficient use of sealed beam lamps. By efficient use is meant reducing considerably the use of light controlling devices, such as gobos, scrims and barndoors.

In general, our tests, coupled with current studio experience, demonstrate that sealed beam lamps can be successfully used on both location and stage sets with good photographic quality and a saving in production time.

Color Committee Report

By HERMAN H. DUERR, Committee Chairman

Ansco, Binghamton, N.Y.

It is the practice to report to the membership from time to time about the work which is being carried on in the different technical committees. Due to the excellent support which the chairman has received from the members of the Color Committee and its subcommittees, it has been possible to make considerable progress on some of the projects the committee has undertaken. This report outlines briefly the present organization, the scope of its activities, what has been done so far, and what is being planned for the immediate future.

There is no scarcity of problems which could or should be tackled by the Color Committee. It is rather a question of doing first things first and giving priority to those problems which are of greatest concern to the industry. Any suggestions from the members will be very much appreciated.

The eighteen members of the Color Committee represent all major organizations actively engaged or involved in the production of color motion pictures.

The objectives of the Color Committee are to make recommendations and prepare specifications for the operation, maintenance and servicing of color motion picture processes, accessory equipment, studio lighting and projection light sources for color, selection of studio set colors, color cameras, color motion picture films, and general aspects of color photography. This is a big order and future chairmen will not have to be afraid of running out of projects in the next five or ten years.

It was agreed at the first meeting of the present committee that it could best serve the Society by working on a progressive program having essentially the following objectives:

1. To survey the existing information on commercially important color motion picture processes and bring that body of information up to date.
2. To analyze and correlate the technical requirements of color motion pictures and evolve recommended practices for the guidance of the industry and as forerunners of future efforts for standardization.
3. To disseminate information as soon as it can be organized and verified for the edification and assistance of the motion picture industry.

Presented: April 27, 1950, at the SMPTE Convention in Chicago.

In order to carry out that program, four subcommittees were organized. Lloyd Varden is Chairman of the color process symposium subcommittee. This subcommittee is working on a review of the literature on color motion picture processes which have attained some measure of commercial success. The chairman is arranging with authors or manufacturers to bring publications about these processes up to date. New processes not yet adequately described in technical publications are to be included in this symposium.

In view of the fact that several new processes for color motion pictures have been on the verge of commercial introduction, the work of this subcommittee has been delayed. It is felt that a thorough and accurate coverage of the processes, even if it has to be somewhat delayed, is preferable to an incomplete or superficial treatment. Your Chairman would like to add a plea here on behalf of the subcommittee chairman for full co-operation of the industry so that the information which is needed to make the report worth while will be made available in the near future.

The Color Symposium Report is not intended as a disclosure of confidential manufacturers' or consumers' techniques. Its primary purpose should be to give a condensed and factual review of the color processes available to the industry.

With a similar intent of providing basic information for the industry, a subcommittee on color film sound track characteristics has been active, with Lloyd Goldsmith as Chairman. This subcommittee has completed its assignment and the report of the committee was printed in the March JOURNAL.

Information about the general principles of color sensitometry has been very fragmentary. It has been recognized by the members of the Color Committee that there is a rapidly growing need for technical information in this field. This is especially true of matters relating to the control of new color processes which have become available to the industry and which can be processed by the motion picture laboratories.

Sensitometric methods are among the most important tools needed to control these processes; therefore, a special subcommittee on color sensitometry was organized to study this problem and provide a report for the guidance of the industry. The membership of the color sensitometry subcommittee has been organized under the chairmanship of Carl F. J. Overhage.

In outlining the scope of the sensitometry subcommittee's activities, no attempt was made to provide an immediate solution to specific problems which may confront the user of color materials. This basic information has to come from the film manufacturer and is

being supplemented daily by the well-known resourcefulness of the laboratory people in the industry. The subcommittee was asked to look beyond these immediate requirements and establish the more fundamental principles involved in color sensitometry and densitometry for future guidance.

Although our present understanding of these processes is still incomplete, it was felt that a report presenting the present knowledge in this field would be very helpful. It also would lead to the formulation of basic methods suitable for use throughout the industry, and thereby eventually prepare the ground for standardization in the field of color sensitometry.

A report entitled "The Principles of Color Sensitometry" has been completed. The report deals with most of the important aspects of color sensitometry and contains sections on:

1. Sensitometric exposure.
2. The processing of sensitometric tests.
3. Quantitative evaluation of color images, dealing with the different types of color densities, such as integral, analytical and equivalent neutral density involved in such evaluation.
4. Densitometer design principles.
5. Transformation between integral and analytical densities.
6. Interpretation of sensitometric results.
7. Statistical aspects of color sensitometry.

Those who had the opportunity to review this committee's report prior to publication unanimously agreed that the subcommittee did a very thorough and highly commendable job. The report was scheduled for publication in the June JOURNAL and reprints will also be made available in quantity because of the considerable demand that already exists for consolidated information on this subject.

Another subcommittee was established some time ago to investigate the spectral requirements of light sources and screens for color projection. Ronald Bingham is the Chairman of this subcommittee, which is working on a report which we hope will be helpful to those branches of the industry engaged in furnishing and maintaining projection equipment and screens. The main emphasis will be given to establishing the theoretically desirable energy distribution of light sources for the projection of all presently available color processes. In this connection, a study of the dye absorption characteristics of commercial two- and three-color processes is being made. At the same time, the spectral distribution of various types of light sources in use for 16- and 35-mm projection is being reviewed. It is not expected that the subcommittee will be able to make definite recommendations; however, in an area in which compromises are necessary

for practical considerations, the subcommittee will attempt to show those compromises which will have the least detrimental effect from theoretical considerations.

Another phase of this program will be a review for recommendations regarding the spectral reflectance characteristics of various types of projection screens for color.

As far as future plans of the Color Committee are concerned, there are at present two subjects on the priority agenda.

At the last meeting of the parent committee in Hollywood, it was suggested that we reopen the subject of phototubes to be used in connection with color film sound track reproduction. In 1947, the Color Committee prepared a report on the subject of blue-sensitive cells for the reproduction of dye tracks. A subcommittee on phototubes, with Lloyd Goldsmith as Chairman, made a study of the blue-sensitive cell and the report of this subcommittee stated that there are no important technical objections to the use of blue-sensitive cells for sound reproduction.

It was the consensus of the Color Committee at the time that the initiative for the conversion of the blue-sensitive cell would have to come from the film manufacturers and the report was temporarily shelved.

As indicated by the review of the subcommittee on color sound track characteristics, published in the March JOURNAL, the tendency has been toward sulfided sound tracks on multilayer color film materials, although it is generally recognized that silver tracks requiring no extra processing steps would be preferable. The advent of the lead sulfide cell, as yet confined to 16-mm projection equipment primarily, makes the whole situation a little more complicated, if not to say, slightly confused.

Little published information is available in regard to the response of lead sulfide cells to silver sulfide or dye tracks on color film. The Color Committee, in co-operation with the phototube subcommittee of the Sound Committee, is now seeking more such information.

Another subject which the Color Committee intends to take up in the near future is the question of color temperature and color temperature measuring instruments as they apply to color photography. It is intended to organize a subcommittee for a study of this subject. The objective of this subcommittee will be to review the theoretical and practical requirements of color temperature measurements in their relationship to color photography.

The Color Committee will welcome suggestions from the members of the Society regarding projects to be tackled by the Committee and which are within the scope of the activities of the Color Committee.

New American Standards

On the following pages appear two recently approved American Standards for scanning beam uniformity test films, and one proposed standard for the sound transmission characteristics of theater screens.

The two test film standards were developed by the joint Society and Research Council Committee on Test Films, and are based on the old war standard Z52.7–1944. In these new standards a departure has been made from past practice in preparing test film specifications in that Appendixes have been included which indicate the methods of using these films and the methods of evaluating the results attained.

The group responsible for the development of these standards believe the Appendixes very desirable because American Standards receive wide circulation and are used by many people not fully experienced in the field of motion pictures.

The proposed standard covering the sound transmission characteristics of theater screens has been developed by the Society's Sound Committee and is also based on a war standard—Z52.44–1945. However, the transmission characteristics specified in this proposal have been met by many types of theater screens which have given satisfactory performance in theaters for over twenty years.

On occasion, screens which have excessive transmission loss have been installed in theaters. When this has occurred, it has been partially offset by raising the gain of theater sound system and changing the equalization. In cases where the power output of the amplifier is close to the upper limit, such a procedure has resulted in excessive distortion.

Therefore, this proposal is being published for a ninety-day trial period. If at the end of that time no adverse criticism has been received, it will be processed as a regular American Standard.

American Standard

Scanning-Beam Uniformity Test Film for 16-Millimeter Motion Picture Sound Reproducers (Laboratory Type)

ASA
Reg. U. S. Pat. Off.
Z22.80-1950
*UDC 778.534.4

1. Scope and Purpose

1.1 This standard describes a film which may be used for determining the uniformity of scanning-beam illumination in 16-mm motion picture sound reproducers. The recorded sound track shall be suitable for use in laboratories and factories.

2. Test Film

2.1 The film shall be a print from an original negative. It shall consist of a 1000-cycle, variable-area recording at full modulation of the 0.005-inch width and shall be approximately sinusoidal. The track shall move uniformly 0.067 inch from one edge of the scanned area to the other as shown in Fig. 1.

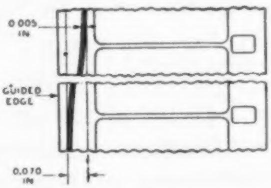


Fig. 1

2.2 The position of the sound track relative to the ends of the light beam at any instant shall be shown by a diagram appearing in the picture area, the size and location of which is shown in American Standard Location and Size of Picture Aperture of 16-Millimeter Motion Picture Cameras, Z22.7-1950, or any subsequent revision thereof approved by the American Standards Association, Incorporated.

2.3 The scanned area shall comply with the American Standard Sound Records and Scanning Area of 16-Mm Sound Motion Picture Prints, Z22.41-1946, and the film stock used shall be cut and perforated in accordance with American Standard Cutting and Perforating Dimensions for 16-Mm Sound Motion Picture Negative and Positive Raw Stock, Z22.12-1947, or any subsequent revisions thereof approved by the American Standards Association, Incorporated.

2.4 The length of this film shall be approximately 34 feet.

NOTE: A test film in accordance with this standard is available from the Motion Picture Research Council or the Society of Motion Picture and Television Engineers.

Appendix

(This Appendix is not a part of this American Standard.)

Before using the above test film it is recommended that correct placement of the scanning beam be determined by means of buzz-track test film as specified in American Standard Specification for Buzz-Track Test Film for 16-Mm Motion Picture Sound Reproducers, Z22.57-1947, or any subsequent revision thereof approved by the American Standards Association, Incorporated.

The uniformity of scanning beam illumination may be measured by means of a db meter connected to the output of the sound projector amplifier. The illumination of the scanning beam should be adjusted according to the instructions furnished by the manufacturer and the variation of the output as registered on the db meter should be observed. The illumination is considered satisfactorily uniform when the output reading as measured by the meter is within ± 1½ db across the entire scanning slit.

Approved June 12, 1950, by the American Standards Association, Incorporated

Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

American Standard

Scanning-Beam Uniformity Test Film for 16-Millimeter Motion Picture Sound Reproducers (Service Type)

ASA
Reg. U. S. Pat. Off.
Z22.81-1950
*UDC 778.534.4

1. Scope and Purpose

1.1 This standard describes a film which may be used for determining the uniformity of scanning-beam illumination in 16-mm motion picture sound reproducers. The recorded sound track shall be suitable for use in the routine maintenance and servicing of the equipment.

2. Test Film

2.1 The film shall be a print from an original negative. It shall consist of a 1000-cycle, variable-area recording at full modulation of the 0.005-inch width and shall be approximately sinusoidal. The track shall move uniformly 0.067 inch from one edge of the scanned area to the other as shown in Fig. 1.

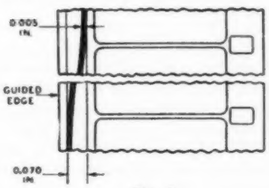


Fig. 1

2.2 The position of the sound track relative to the ends of the light beam at any instant shall be shown by a diagram appearing in the picture area, the size and location of which is shown in American Standard Location and Size of Picture Aperture of 16-Millimeter Motion Picture Cameras, Z22.7-1950, or any subsequent revision thereof approved by the American Standards Association, Incorporated.

2.3 The scanned area shall comply with American Standard Sound Records and Scanning Area of 16-Mm Sound Motion Picture Prints, Z22.41-1946, and the film stock used shall be cut and perforated in accordance with American Standard Cutting and Perforating Dimensions for 16-Mm Sound Motion Picture Negative and Positive Raw Stock, Z22.12-1947, or any subsequent revisions thereof approved by the American Standards Association, Incorporated.

2.4 The length of this film shall be approximately 3½ feet.

NOTE: A test film in accordance with this standard is available from the Motion Picture Research Council or the Society of Motion Picture and Television Engineers.

Appendix

(This Appendix is not a part of this American Standard.)

Before using the above test film it is recommended that correct placement of the scanning beam be determined by means of buzz-track test film as specified in American Standard Specification for Buzz-Track Test Film for 16-Mm Motion Picture Sound Reproducers, Z22.57-1947, or any subsequent revision thereof approved by the American Standards Association, Incorporated.

The uniformity of scanning beam illumination may be measured by means of a db meter connected to the output of the sound projector amplifier. The illumination of the scanning beam should be adjusted according to the instructions furnished by the manufacturer and the variation of the output as registered on the db meter should be observed. The illumination is considered satisfactorily uniform when the output reading as measured by the meter is within ±1½ db across the entire scanning slit.

Approved June 12, 1950, by the American Standards Association, Incorporated

Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

PROPOSED AMERICAN STANDARD

Sound Transmission of Theater Projection Screens

Z22.82

1. Sound Transmission Characteristics

1.1 The sound transmission characteristics of theater projection screens shall be such that the attenuation at 6000 cycles per second, with respect to 1000 cycles per second, is not more than 2½ db and the attenuation at 10,000 cycles per second, with respect to 1000 cycles per second, is not more than 4 db. The regularity of response shall be such that there is no variation greater than ± 2 db from a smooth curve at any frequency between 300 and 10,000 cycles per second. The general attenuation at and below 1000 cycles per second should not be greater than 1 db.

2. Method of Measurement

2.1 The sound transmission of the screen shall be measured by means of a loudspeaker, fed by an audio oscillator and amplifier, behind the screen, and a calibrated microphone, amplifier and output meter in front of the screen. The loudspeaker shall be of the type normally used in motion picture theaters for the size of screen being tested, and shall be placed so that no part of the loudspeaker is less than 2 feet from an edge of the screen with its mouth parallel to and separated from the screen by the recommended theater installation distance of from 4 to 8 inches (center cell in the case of a curved front multicellular horn). The microphone shall be located 10 to 12 feet in front of the screen and on the axis of the loudspeaker. The sound transmission of the screen at any frequency is then the difference in the sound level measured with the screen in place and with the screen removed.

2.2 Suitable precautions shall be taken to eliminate or minimize the effect of standing waves in the test room both in front of and behind the screen.

NOT APPROVED

68th Semiannual Convention

Society members will meet on October 16 for their 68th Semiannual Convention. The Lake Placid Club, a restful private resort in the heart of the Adirondacks, will be the location. Bill Kunzmann, the Society's genial Convention Vice-President invites all members to attend, relax in delightful informal surroundings and derive maximum value from the many technical papers soon to be scheduled. The Papers Committee gives assurance that the program will be well organized, and that it will attempt to provide more adequate opportunity for discussion than has been customary for conventions in the recent past.

The growing scope of the Society's interests makes necessary adopting this and certain other practices now customary with the larger engineering societies. More efficient management of the program should result, with greater net benefit to members who attend technical sessions. Nine technical sessions are being scheduled—the first, including a Business Meeting, is to begin at 2:00 P.M., Monday, October 16. Differing somewhat from the format of previous conventions, the Monday evening session will feature the introduction of Officers and Governors-Elect and presentation of the Society's five major awards. The last session should end at about 5:00 P.M., Friday, October 20.

Previous conventions have had their lighter side, and the 68th is no exception. The Wednesday night Cocktail Party and Banquet are to be followed by a Costume Dance in which all who attend will participate and compete for recognition. Costumes will be as simple or as elaborate as the participants may desire.

Bill Kunzmann has announced appointment of the following Convention Committee Chairmen and asks that the membership give all possible aid to making the 68th Convention the best of all.

Local Arrangements, E. I. Sponable and W. C. Kunzmann
Papers Committee
Chairman, N. L. Simmons
Vice-Chmn., Montreal, H. S. Walker
Vice-Chmn., Chicago, R. T. Van Niman
Vice-Chmn., New York, E. S. Seeley
Vice-Chmn., Hollywood, L. D. Grignon
Vice-Chmn., Washington, J. E. Aiken
Publicity, Chairman, Harold Desfor
Registration and Information, E. R. Geib, assisted by P. D. Ries
Banquet, Hotel Reservations and Transportation, W. C. Kunzmann
Membership and Subscriptions, Chairman, Lee Jones
Assisted by A. G. Smith, Atlantic Coast Section Vice-Chairman
Projection and Public Address Equipment, E. S. Seeley
Ladies Reception Committee, Mrs. E. I. Sponable, Hostess
Co-hostess, Mrs. O. F. Neu

High-Speed Photography Question Box

Extensive use of high-speed motion pictures—and their corollary, time-lapse photography—as research tools is forcing many an engineer to become an accomplished photographer, to add to his other highly specialized experience. He puts the unfamiliar tools of photography to work because he has available no other means of securing the information he needs. Although photography in its more conventional aspects is basically complex, our researcher multiplies its complexities many times by crowding to the limit nearly every step in the process and thereby hands himself, as an amateur, a handful of problems that have been stumping the experts regularly for years.

Formal aids, such as high precision cameras, accessory optical devices, exposure measuring instruments and control mechanisms, already exist. Information about them has appeared in the JOURNAL and in a number of other publications, but very little has been written about techniques essential to good photographic results with cameras, film and processing under marginal operating conditions. To help fill this need, the JOURNAL will in the future carry periodically a High-Speed Photography 'Question Box' wherein an exchange of questions and answers will provide some measure of continuous technique orientation for users of high-speed or other scientific applications of photography.

There is little doubt that in many cases the problem in one laboratory will find a practical solution from the experience of another. If you have answers to the few questions that appear below, please communicate with Bill Deacy, Society Staff Engineer at the New York office. He will transmit your solution to the person who has the problem and will arrange for the answer to be published in a forthcoming issue of the JOURNAL.

Q1. High-speed motion pictures are required of moving parts inside a black bakelite device smaller than a dime and about ½ in. deep. An Eastman camera is used operating at 4,000 and 8,000 frames/sec with the camera 13 in. from the object which is illuminated by a pair of No. 2 reflector spots placed 6½ and 7½ in. away. A 2-in. lens is operated at $f/2$ with a +3 portrait auxiliary attachment. Insufficient exposure is obtained using Super XX film, and the heat generated is such that it alters the performance of the device under test. How can the illumination be increased and the heat removed? What new lighting equipment or techniques should be used?

Q2. Motion pictures are being photographed with a 16-mm Fastax Camera at 1250 frames/sec, using a 6-in. lens, object distance of 8 ft, Super XX reversal film and two 750-w reflector spot lamps. The subject consists of small parts of a mechanical device, moving at the rate of 15 to 30 cycles/sec. Specular reflections from bright wearing surfaces can be controlled with polarizing filters, but nearly all other surfaces are machined with similar finish so that adjacent moving parts or areas of intermittent contact are difficult to distinguish in the projected pictures. How can these several parts be made to stand out more clearly?

Q3. A manufacturer of air-borne instruments needs motion picture records of vibration effects on components of his equipment. The instruments under study are small and encased, making it necessary to illuminate and photograph through a hole in the cover. Vibration frequencies as high as 800 cycles/sec, with total object motion at times of as little as .001 in. must be observed. Is it possible and practical to study these phenomena with high-speed motion pictures; and if so, what type of camera, lens, exposure meter and what frame frequencies will be required? Also, what light source should be employed in the initial setup?

Q4. How can a 3 × 5 ft area of a dark machine be adequately lighted for photography at a frame frequency of 3,000? High amperage lines are not available.

Q5. Is special processing for reversal film available to users of high-speed photography? Longer first development would be helpful when film is known to be underexposed.

Engineering Committees

Magnetic Recording

The Magnetic Recording Subcommittee under the chairmanship of Glenn Dimmick has drawn up and circulated proposed dimensional standards for magnetic sound tracks on 35-, 17½-, and 16- and 8-mm motion picture film. These proposals are the result of a three-year attempt to develop standards that will meet with universal approval. While isolated opinions hold that some further modifications may be necessary, it is the majority opinion that publication and wide circulation of the current proposals will help crystallize thinking and lead to ear ier agreement.

Of particular interest in the amateur field is the proposed standard for 8-mm magnetic tracks which will permit the addition of sound to 8-mm motion picture films. Several manufacturers are now preparing to announce 8-mm projectors with magnetic sound reproducers. If these standards, possibly with some modification, can be accepted soon, a tremendous saving for the manufacturers and the ultimate users will be realized. Early agreement will also prevent great confusion which will result if 8-mm sound films are not interchangeable among the projectors of various manufacturers.

These proposals cannot be scheduled to appear in the Journal in less than sixty days, but draft copies are available from Society headquarters. If you wish to review them prior to publication, write Bill Deacy at headquarters, and he will be glad to supply you.

New Release Print Leader

Charles Townsend's Subcommittee of the Films for Television Committee is working on a proposed first version of a revised type of release print leader. The project was undertaken several months ago when the television broadcasters announced that the Academy leader Z22.55 does not meet their needs in at least three important respects. Precise timing of films, necessary in television broadcasting, is not possible. The long series of black frames immediately preceding the picture cause excessive flare under conventional television switching procedures and also prevent the control engineer from anticipating the normal picture gain setting for the picture coming up. Mechanical alignment of projectors and television cameras is particularly critical and should be checked, at least approximately, before every picture goes on the air.

From the outset, it was agreed that any new leader must fill the needs of both television and theater interests and should work well on both 35- and 16-mm release prints if it were to be unanimously accepted. Otherwise, serious confusion would be caused in film laboratories and exchanges by two types of leaders.

A 35-mm negative of the new proposal will be available very shortly. If you desire a trial print, Society headquarters will be glad to supply one in either 16- or 35-mm width.

Society Announcements

New Sustaining Member

The Society is pleased to welcome Neumade Products Corp. as the most recent addition to the rolls of our Sustaining Members. The total now stands at 73, with several more now negotiating. The financial support provided furnishes tangible evidence of faith in the Society's engineering committee work, and makes it possible for more projects to be undertaken and a higher percentage to be completed each year. The ambitious publications program, which includes not only the Journal but also reports and symposia, also benefits all members.

The Index for Volume 54 was tacked by two spots of adhesive to the inside back cover of the JOURNAL proper in June in an effort to serve both those who have wanted the Index bound in the last issue of a volume and those who have as definitely wanted to receive Indexes as separately bound booklets.

The spine of the Journal beginning with this issue, shows a rearrangement made in an effort to show more clearly the progression and identity of numbers within each volume. This has been done chiefly in response to very helpful suggestions made by Lorin D. Grignon, Development Engineer of Twentieth Century-Fox.

Briefly Noted

Radio and Television Law, by Harry P. Warner, 1,095 pp., $35.00, has been recently published by Matthew Bender & Co., Albany, N.Y. The author is known to JOURNAL readers as the coauthor, with J. E. McCoy, of "Theater Television Today," in the October, 1949, JOURNAL. Detailed information about the book is available in the form of an advertising letter from the publishers.

Radiofile is an index of radio and television articles appearing in the principal technical periodicals. This JOURNAL has been added to those previously indexed. *Radiofile* is an index by subject, not by title. It is issued bimonthly and is cumulative, listing all material of the current year, so that only the last index need be consulted. The year-end Annual is for permanent reference. The yearly subscription rate is $1.50. Annuals are: for 1946, $.35; and 1947-49, $.50 each. The publisher is Richard H. Dorf, 255 W. 84 St., New York 24.

"Management Techniques to Match Speed With Efficiency" is an article on common sense management by W. Walter Watts in the May, 1950, *Dun's Review.* "Wally" Watts is well known to Society members as Vice-President of RCA and a major proponent of theater television. In this article he speaks of coaching an industrial organization from within rather than managing from above, as a practical and successful way of enabling it to self-adjust to fast changing conditions. His is a philosophy that will interest all who are administrators in any industry. *Dun's Review* is 35¢ a copy, from Dun and Bradstreet, 290 Broadway, New York 8.

New Members

The following have been added to the Society's rolls since the list published last month. The designations of grades are the same as those in the 1950 MEMBERSHIP DIRECTORY:
Honorary **(H)** Fellow **(F)** Active **(M)** Associate **(A)** Student **(S)**

Adams, Stanley H., Factory Representative, Movie-Mite Corp. Mail: 10609 W. 62 St., Shawnee, Kan. **(A)**

Bearman, Alexander A., Engineer, Twentieth Century-Fox Film Corp. Mail: 444 W. 56 St., New York 19. **(M)**

Bennett, Stanton D., Radio Engineer, Radio Station KOMO. Mail: 3437 36 Ave. W., Seattle 99, Wash. **(A)**

Choudhury, Siraj-ul-Islam, College of the City of New York. Mail: 150-8 Suffolk St., New York 2 (Apt. 17). **(S)**

Claybourne, J. Philip, Design Engineer, J. A. Maurer, Inc. Mail: 48 Avenel St., Avenel, N.J. **(A)**

Coleman, Theodore T., Motion Picture Producer. Mail: 12610 Brackland Ave., Cleveland, Ohio. **(A)**

Cook, Edmund G., Jr., Deputy Chief, AMC Photo Service Center, WP-AFB, Mail: Box 1107, Wright-Patterson Air Force Base, Dayton, Ohio. **(A)**

Daniels, Victor J., Daniels High Speed Motion Picture Corp. Mail: 395 Barry Rd., Rochester 17, N.Y. **(A)**

Edwards, Charles N., Photographic Engineer, U.S. Naval Photographic Center. Mail: 2952 Second St., S.E., Washington, D.C. **(M)**

Fallier, Jeptha D., Camerman, Television Features. Mail: 31-84—33 St., Long Island City, N.Y. **(M)**

Gippner, Gerald O., Technical-Engineering Staff, Movie-Mite Corp. Mail: 2114 Cleveland Ave., Kansas City, Mo. **(A)**

Goldberg, Morris M., Motion Picture Photographer, Armed Forces Institute of Pathology. Mail: 245 Gallatin St., N.W., Washington 11, D.C. **(A)**

Gordon, Larry, Producer and Director, Television Features, Inc.; General Business Films, Inc. Mail: 480 Lexington Ave., New York 17. **(M)**

Halprin, Sol, Executive Director of Photography, Twentieth Century-Fox Films. Mail: 101 S. Vista St., Los Angeles 36, Calif. **(M)**

Ham, Richard T., Instructor, Motion Picture Photography, The Art Center School. Mail: 849 S. Kenmore St., Los Angeles 5, Calif. **(A)**

Hatcher, George D., Teacher–Television Projectionist, Johnstown City Schools and WJAC-TV. Mail: 1184 Agnes Ave., Johnstown, Pa. **(A)**

Hatcher, Herbert E., Product Designer, Bell & Howell Co. Mail: 701 Ridge, Evanston, Ill. **(A)**

Hershman, J. B., President, Radio and Television School, Valparaiso Technical Institute, Valparaiso, Ind. **(A)**

Hessler, Gordon, Film Editor, Films for Industry. Mail: 105 Riverside Dr., New York 24, N.Y. **(A)**

Holmes, Porter, Boston University. Mail: 24 Park St., Brockton 48, Mass. **(S)**

Inderwiesen, Frank H., Radio–Television Engineer, Universal Television School. Mail: 1116 W. 40 St., Kansas City 6, Mo. **(A)**

Leopold, Rudolf, General Mechanical Engineer, A. B. Du Mont Laboratory. Mail: Demarest Ave., Oakland, N.J. **(M)**

Levey, Lawrence, Editor–Publisher. Mail: 304 W. 92 St., New York 25, N.Y. **(A)**

Linden, Michael, Librarian, Motion Picture Association of America, Inc. Mail: 168 Washington Park, Brooklyn 5, N.Y. **(M)**

Lockwood, Harold A., Television Engineer, Farnsworth Television & Radio Co. Mail: 3216 Central Dr., Fort Wayne, Ind. **(A)**

Matheson, Ralph G., President and General Manager, Matheson Company, Inc. Mail: 75 Greaton Rd., West Roxbury, Mass. **(A)**

McIntosh, James S., Assistant Director, Educational Services, Motion Picture Association of America, Inc. Mail: 7813 Stratford Rd., Bethesda, Md. **(M)**

McKnight, Boyd E., Engineer, Minnesota Mining & Manufacturing Co. Mail: 446 N. LaBrea Ave., Los Angeles 36, Calif. **(A)**

Miller, Thomas H., Manager, Photographic Training Dept., Eastman Kodak Co., 343 State St., Rochester 4, N.Y. **(A)**

Montes, Ventura, Technical Adviser, CMQ Radio Broadcast & TV. Mail: Calle A bet. 7th & 9th, Playa Miramar, Habana, Cuba **(A)**

Phillips, William D., University of Southern California. Mail: Hickory Hill, Claremore, Okla. **(S)**

Sadkin, Marvin W., Motion Picture Laboratory Technician, George W. Colburn Laboratory, Inc. Mail: 2925 W. 56 St., Chicago 29, Ill. **(A)**

Sandell, Maynard L., Engineer, Eastman Kodak Co., 343 State St., Rochester 4, N.Y. **(M)**

Thompson, Orville I., Superintendent, DeForest's Training, Inc. Mail: 2533 N. Ashland Ave., Chicago 14, Ill. **(M)**

Van Weyenbergh, C., Manager, Western Electric Co. (France). Mail: 20, Place des Martyrs, Brussels, Belgium. **(A)**

Wilson, Willett R., Chief Engineer, Photolamp Section, Westinghouse Electric Corp. Mail: 45 Glenbrook Rd., Morris Plains, N.J. **(M)**

Young, Robert P., Sales, General Aniline & Film Corp., Ansco Division. Mail: 95 Beekman Ave., North Tarrytown, N.Y. **(A)**

Letter to the Editor

With reference to Mr. Cummings' letter in the June Journal (p. 766), it is noted that the words "the soda ash residue that remains. . ." ignore my previous statement ". . . that this film was clean and free of any extraneous matter when it ignited."

There is absolutely no sodium hydroxide, or soda ash as some call it, present on the washed and dried film because the material receives a very thorough cleaning, both mechanically and by washing, and it is well known that sodium hydroxide is very soluble. Furthermore, any minute trace that might be present would cease to

exist as sodium hydroxide and would be converted into the products of reaction between it and the gelatin, and any that might still then be left would be changed into sodium carbonate, also very soluble.

The chance of accidental contamination with sodium hydroxide is quite remote because of the method of the washing of the film.

Mr. Cummings describes the control in nitration as so accurate that there would be very little chance of overnitration.

Without going into too involved a chemical explanation, it is readily conceivable that cotton, being a natural product, does not always produce cellulose in exactly the same way; differences due to soil, weather, accidental injury to the plant and other factors would tend more or less to alter the cellulose, and it is quite possible that under these varying conditions some cellulose of the cotton might be susceptible to further nitration.

The writer has seen a blowout occur right at the nitrating spot in a chemical plant. The operators thought nothing of it, saying that it was a thing to be expected. The nitration kept right on regardless of the blowout because the plant was constructed in such a way that it could take care of it. Why did the blowout occur if the control is so perfect?

It is realized that spontaneous combustion due to high nitration is fortunately rare, but who knows exactly how rare? The point to stress is that with such a substance as cellulose nitrate, the storage conditions should be such as to insulate the fire when it *does occur*, a general point on which both the writer and Mr. Cummings agree.

June 22, 1950 JOSEPH H. SPRAY

Book Review

Handbook of Basic Motion-Picture Techniques, by Emil E. Brodbeck

Published (1950) by Whittlesey House (McGraw-Hill), 330 West 42d St., New York 18. i-xiii + 307 pp. text + 3 pp. index. Profusely illus. 6 × 9 in. Price $5.95.

"Right at the outset of this book," says the author right at the outset of his preface, "there are a few vital truths which you should know. First is the fact that the *technique* of making motion pictures and the *mechanics* of making them are two different things. Technique is the 'art' and 'skill' of movie making. The mechanics of movie making are such things as learning to focus, to expose your film correctly, to load and wind your camera."

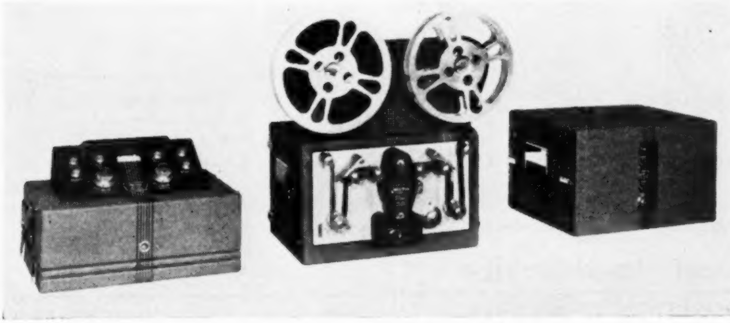
To members of SMPTE and readers of the JOURNAL, the mechanics of movie making should be an old story. Mr. Brodbeck's first 48 pp., therefore, may well not hold for them anything helpful or revealing. The bulk of his book, however, in which in ten major chapters he discusses the "techniques" of movie making should be of interest (and perhaps aid) to the practicing technician, especially if he makes movies on the side as a personal hobby.

Mr. Brodbeck's ten chapters take up such subjects as panning, using the tripod, shot breakdown, screen direction, matching action, newsreel technique, build-up, composition, indoor lighting and applied techniques. Each chapter presents the subject in the form of a lesson—with text, practice assignments and rules to remember. Mr. Brodbeck's approach to his subject is vigorous and forthright, his illustrations practical and informative. On the whole, however, the pictures suffer throughout this volume from muddiness of reproduction.

JAMES W. MOORE
Home Movies
New York, N.Y.

New Products

Further information concerning the material described below can be obtained by writing direct to the manufacturers. As in the case of technical papers, publication of these news items does not constitute endorsement of the manufacturer's statements nor of his products.



The Westrex 1035 Magnetic Recording System is a fixed studio or portable location recording system for the use of 35-mm magnetic film at a forward recording speed of 90 fpm and a reverse rewind speed of 270 fpm.

To take full advantage of the inherent signal-to-noise ratio of 35-mm magnetic film, a new line of amplifiers having exceptionally low noise has been developed. The transmission circuit consists of three amplifiers, two microphone preamplifiers, and one main recording amplifier, all basically identical, small in size and with a normal flat gain of 70 db from 30 to 10,000 cycles. Their frequency characteristic may be changed by means of interstage plug-in equalizer units.

The RA-1467-A Magnetic Recorder is driven by a single-phase, 50- or 60-cycle, 115-v, synchronous motor, but can also be supplied for operation with a three-phase, 50- or 60-cycle synchronous motor, an interlock motor, or a multi-duty combination of 220-v three-phase synchronous and 96-v d-c motor. Flutter, or "wow," has been reduced to a negligible value.

Position and dimensions of the recorded magnetic sound track are in accordance with the proposed Standard 58.301-B of the Academy Research Council. The recorder is convertible for use with 16-mm or 17½-mm magnetic film.

Tight loop threading path is used. The magnetic recording head is mounted at the point of optimum scanning and the monitor head is offset for magnetic monitoring of the recorded signal. Both the recording and monitor head circuits terminate in a single plug and jack connection within the enclosure which can be easily reversed to permit using the recording head to reproduce at the point of optimum scanning. Consequently the recording machine can also be used as a high-quality magnetic re-recording reproducer.

A driven footage counter adds on the forward run and subtracts on the reverse rewind to keep accurate count of film footage.

The RA-1484-A Power Control Unit contains a newly developed power supply, both line and load regulated, operating from a power source of 115-v, single-phase, 50- or 60-cycles. The Control Unit also contains the magnetic bias oscillator and the magnetic film monitoring amplifier.

The entire system is easily transportable and weighs approximately 190 lb, including all interconnecting cables. Further information is available from Westrex Corp., Hollywood Div., 6601 Romaine St., Hollywood 38, Calif., or Westrex Corp., 111 Eighth Ave., New York 11, N.Y.

The Line-Up Viewfinder is announced by the Hollywood Camera Exchange as the first light-weight "Zoom-type" viewfinder combining both the 16-mm and 35-mm fields, giving the proper perspective of the scenes being photographed, as well as the area covered by any lens. Useful for predetermining the proper lens, whether it be a telephoto or an extremely wide-angle lens, the calibrations range from 13- to 75-mm for 16-mm film and from 25- to 150-mm for 35-mm film. It is not convertible for 8-mm use and it is not to be used as an auxiliary lens; nor is it designed to be attached to any camera. It measures 1⅛ in. in diameter by 3½ in. long and weighs 2 oz, being carried about the neck on a cord or in one's pocket. The price is $15.50, f.o.b. Hollywood. Other information is available from the Hollywood Camera Exchange, 1600 Cahuenga Blvd., Hollywood 28, Calif.

Employment Service

POSITION AVAILABLE

Wanted: Individual who has had practical paid experience in the audio-visual field; must have knowledge of film storage procedures, circulating and maintenance of film, evaluation and catalog preparation. Must be able to meet the public and to supervise. Write: R. E. Herold, 5069 Montezuma St., Los Angeles 42, Calif.

POSITIONS WANTED

Cameraman - Director: Thorough knowledge of script-to-screen technique. Capable of own script preparation and production; 6 yr experience free-lance cameraman and producer; adept with all types 16-mm photographic and editing equipment. Wish permanent position with 16-mm industrial or TV producer; age 27, single, free to travel, details readily supplied. Robert Deming, 343 S. 13 East, Salt Lake City, Utah.

Producer-Director-Editor: 10 yr with major film producers. Thorough knowledge and experience script-to-screen production technique: directing, photography, editing, laboratory problems, sound recording, 35- and 16-mm, b & w and color. Specialist in research and prodn. of educational and documentary films; small budget commercial and TV films. Long experience in newsreels. Desire greater production possibilities, go anywhere. Member SMPTE, top refs. E. J. Mauthner, P. O. Box 231, Cathedral Sta., New York 25.

Mechanical-Electronic Engineer: B.S. degree in Mechanical Engineering; extensive design, mfg. experience, standard and drive-in theater picture and sound equipment; experience as engineering assistant to top management exec. corp. in radio TV. Write A. Kent Boyd, 3308 Liberty St., Austin, Texas.

On-the-Job G.I. Bill Training: Ambitious young man to be member of camera crew; grad. U.S. Army Signal Corps Schl.; experienced with Cine Spec., 70DA, Eyemo, Wall and Mitchell cameras; studied editing, art directing and cinematic effects at U.S.C.; married, non-drinker, serious; man for small studio TV work. P.O. Box 524, Alhambra, Calif.

SMPTE Officers and Committees: The roster of Society Officers was published in the May JOURNAL. The Committee Chairmen and Members were shown in the April JOURNAL, pp. 515–22; changes in this listing will be shown in the September JOURNAL.

What kind of *Journal* do *you* want?

Catching up or keeping up with new developments in any field as they come along calls for plenty of required reading. For members whose major technical interests are motion pictures or certain areas of television, and whose reading time is at a minimum, the *Journal* attempts to provide broad competent coverage giving a lot in a small package. Technical articles, reports of progress in Society committee work, reviews of recent technical books, descriptions of new products, and references to current periodical literature which appear in each issue are as timely as publication schedules permit. Permanent reference value also is a major criterion in the selection of such material so that if the contributing authors and the editors are fulfilling their obligations, both members and subscribers should receive each month a well-rounded complement of information with clues to additional worth-while sources.

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Boyce Nemec
Executive Secretary

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